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RIP (1012)

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SANTA CRUZ TEST BASE
Briefing by Agena Division
17 January 1961

WDZYA

Presented by
Lt Colonel Oliver

1 Jan 61

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SANTA CRUZ TEST BASE OPERATIONS
SUMMARY OF SIGNIFICANT FINDINGS

SUBSYSTEM A - AIRFRAME

Improved Seals Resulted From Test Findings
Turbine Exhaust Stack Mounting Marginal
Separation Monitor Noise
Tank Seal Deterioration Problem Solved
Structural Problem Revealed in Forward Equipment Rack

SUBSYSTEM B - PROPULSION

Engine Performance Verification
Defective Pressure Regulator
Thrust Chamber Transducer Failure
Relay Box Vibration
Unreliable Engine Liquid Regulator
Improved Thrust Chamber Welding
Ox Pump Housing Leak
Ox Manifold Pressure Switch Boss Leak (Agena D)
Magnesium Chips in Turbine (Agena D)
Secondary Propulsion System Performance Verification
Orifice Pressurization System Performance Verified
Agena D Propulsion and Orifice Pressurization Verification
Isolation Valve Failures
Flushing or Fill and Drain Requirements

SANTA CRUZ TEST BASE OPERATIONS

SUMMARY OF SIGNIFICANT FINDINGS (cont'd)

SUB SYSTEM C POWER

Inadequacy of Aluminum Wiring
Microphonics in Power Supplies Revealed
Guidance Amplifier Power Supply Instability
Pyrotechnic Fusistor Mounting Failed under Engine Vibration

SUB SYSTEM D GUIDANCE

Sticking Pitch Gyro, Intermittant Horizon Scanner, D-Timer Switch Failures, Noisy Integrator Circuit
Deficiencies in N_2 Gas Valve Transducers
Gas Jet Assembly Susceptibility to Vibration
Hydraulic Package Failure
Horizon Sensor Mounting Bolt Problem

SUB SYSTEM C & C COMMUNICATIONS AND CONTROL

Typical; Ruptured Oxidizer Pressure Transducer

SIGNIFICANT FINDINGS

SUBSYSTEM A

STEEL SEALS SUBSTITUTED FOR ALUMINUM SEALS - Oxidiser leakage traced to aluminum tank seals which were found to be nicked and scratched thereby not providing good seal. Steel seals more durable and less susceptible to such minor but critical damage were substituted.

TURBINE EXHAUST STACK MOUNTING BRACKET - Shown to be of marginal design in that it lacked the necessary rigidity. During test at SCTB it became loosened. This situation could have resulted in a possible problem during actual flight conditions. To positively preclude such a possibility the bracket was re-designed.

SEPARATION MONITOR NOISE - During engine firing the separation monitor produced high noise level blanketing telemetry transmission.

TANK SEAL DETERIORATION - Tank seal leakage noted under actual operating conditions at Santa Cruz showed that seals for propellant tanks, fuel and oxidiser seals were reversed in installation causing eventual and sometimes rapid deterioration. Such a situation could only be uncovered under actual operating conditions.

IMPROVED SEALS RESULTED FROM TEST FINDINGS - As a result of continuing testing and operating experience, steel seals were found to have significant difficulty in obtaining proper compression and seal. A composition seal which is compatible with the propellants utilised was discovered and is now in service.

STRUCTURAL PROBLEM REVEALED IN FORWARD EQUIPMENT RACK - In investigating horizon-sensor vibration problems encountered in Santa Cruz Captive Test, vibration tests at Sunnyvale on the forward equipment rack revealed a structural problem. The structure was strengthened, correcting the problem.

SIGNIFICANT FINDINGS

SUBSYSTEM B

ENGINE PERFORMANCE VERIFICATION - One of the most important products of the complete vehicle systems at the Santa Cruz Test Base is that of Engine Performance Verification. Each vehicle tested is instrumented to measure the necessary parameters. A case in point is Discoverer XIX (1101 - RM - 1). The engine, a suspected low performer, SCTB test results showed that the specific impulse (Isp) was seven (7) seconds low. Results - Additional propellants were loaded - Flight went to integrator shutdown with indications of very small residuals.

DEFECTIVE PRESSURE REGULATOR - Found faulty operation under actual hot firing conditions. Inspection revealed discrepent casting and oversize spring. Entire lot re-inspected eliminating probability of recurrence on an actual flight.

THRUST CHAMBER TRANSDUCER FAILURE - Pressure transducer measuring thrust chamber pressure failed during early test. Found improper location, welding and support. Failure during flight could have resulted in thrust chamber failure and resultant destruction.

RELAY BOX VIBRATION - Tolerance limits proven low during hot firing test causing a premature shutdown. Incident proved that safety margin had to be added. Demonstrated that environment produced at SCTB useful and better source than machine. Production units changed.

UNRELIABLE ENGINE LIQUID REGULATOR - Original Agena A engine Model 8001 showed unreliable operation of engine liquid regulator. The regulator, a mechanical device, delivered 70% of normal flow to the gas generator, the remaining 30% being controlled by a bellows tap for constant RPM. Santa Cruz testing showed possible clogging due to salting with special handling and flushing required. This was a major factor in the gas generator re-design incorporated in subsequent engines.

IMPROVED THRUST CHAMBER WELDING - Testing at Santa Cruz revealed faulty welds in the thrust chamber and oxidizer manifold assembly. Called to the immediate attention of Bell Aerosystems Co., improved welding and assembly techniques resulted.

SIGNIFICANT FINDINGS

SUBSYSTEM B (Continued)

OX PUMP HOUSING LEAK - Post-test inspection indicated oxidizer leakage during test in engine area. Post-test leak checks pinpointed leak to ox pump housing seal. Normal pre-fire checks gave no indication of leakage in this area.

OX MANIFOLD PRESSURE SWITCH BOSS LEAK (AGENA D) - An AN bulkhead union with recess for backup gasket was installed in the OMP thrust chamber boss by Bell Aerosystems. This fitting had been modified by cutting the mating flare end off. Tight fitting recess caused an improper seal of the boss O-ring which in turn leaked at high pressure. None of the normal leak checks indicated leakage. The leak was pinpointed by motion picture coverage during the hot fire test.

MAGNESIUM CHIPS IN TURBINE (AGENA D) - The engine on Agena D PTVA had a magnesium oil dam installed in the turbine drive assembly. During the course of testing, this dam worked loose causing magnesium from the dam to be ground off entering the pump gearbox. All bearings and seals in the pump were replaced and the magnesium dam was retrofitted by a substitute stainless steel dam of later design.

SECONDARY PROPULSION SYSTEM PERFORMANCE VERIFICATION - The secondary propulsion system was tested utilizing multiple starts and various hold periods. Various hardware problems with salting were encountered. However, generally the propulsion system was very successful. The salting problems initiated an improved technique of flushing to eliminate salt formation. During the course of the testing, GSE and launch base techniques were established and GSE design verified.

ORIFICE PRESSURIZATION SYSTEM PERFORMANCE VERIFIED - The orifice pressurization system was tested semi engine to determine optimum orifice sizing and general design concepts for final design criteria. All objectives successfully met.

AGENA D PROPULSION AND ORIFICE PRESSURIZATION VERIFICATION - The orifice pressurization system was tested in conjunction with engine firings to determine system compatibilities and also to determine the validity of using the electronic computer to establish design characteristics and blowdown curves. All objectives were met.

ISOLATION VALVE FAILURES - Various isolation valve failures occurred with the general controls propellant isolation valve. One of these failures occurred during the course of the hot firing causing a malfunction of the engine. The reliability of the general controls valve was tested with special tests as a direct result of this firing failure. Design improvements and/or substitution of valve with Parker designed valve were indicated as desirable from accomplished tests.

SIGNIFICANT FINDINGS

SUBSYSTEM B (Continued)

FLUSHING OR FILL AND DRAIN REQUIREMENTS - A continuous effort has been established to improve the fill and drain (flush) techniques and to establish confidence levels in vehicle cleanliness. An outgrowth of this effort was the establishment of legitimate contamination levels. The tri-flush technique was eliminated in vehicles which had not been exposed to propellants thus decreasing the time required to meet cleanliness requirements.

SIGNIFICANT FINDINGS

SUBSYSTEM C

INADEQUACY OF ALUMINUM WIRING - After hot firing at Santa Cruz a number of broken leads were discovered. The crimp connectors were cutting the aluminum were under vibration during engine firing. The aluminum was found to work-harden under crimping action. This was compounded by a personnel error in using an improperly sized crimping tool. The latter was a quality assurance inspection problem which was corrected and the aluminum wire was replaced by a copper wire. The difficulty might never have been discovered without a hot firing.

INSTABILITY OF GUIDANCE AMPLIFIER POWER SUPPLY - Instability in the IRP amplifier had been noticed in Sunnyvale systems runs but could not be corrected because it was intermittent. The long land lines and checkout system at Santa Cruz introduce more electronic noise and more frequent stimulation of these amplifier oscillations. Since the condition was more prevalent at Santa Cruz it was isolated, identified, and corrected there. The trouble involved coupling with the minus 28 volt power supply. The remedy involved increasing the power supply capacity from 30 watts to 100 watts, reducing its output impedance, and redesigning the amplifier to inhibit oscillation.

MICROPHONICS IN POWER SUPPLY REVEALED - After 10 seconds of engine firing during the Santa Cruz static test of MIDAS vehicle 1006, extensive noise appeared on the minus 28 volt power supply and plus 28 volt regulator, with an amplitude of +2volts. The noise continued for the duration of the engine firing. Although the source of this trouble was never identified, the vehicle was extensively reworked and suspected components were replaced. The condition was absent during a subsequent hot firing. It was thought to indicate loose wiring which might have existed during flight if undiscovered during the hot firing.

PYROTECHNIC FUSISTOR MOUNTING FAILED UNDER ENGINE VIBRATION - Encapsulated fusistor circuits were subject to breakage by vibration when installed in the vehicle. One ullage rocket circuit failed during engine firing. The circuit to actuate the mechanical release on a payload failed during engine vibration. The method of mounting fusistors was re-designed.

SIGNIFICANT FINDINGS

SUBSYSTEM D

STICKING PITCH GYRO - INTERMITTENT HORIZON SCANNER - D TIMER SWITCH FAILURES and NOISY INTEGRATOR CIRCUIT - The foregoing four items were malfunctions occurring during hot firing at Santa Cruz. Components affected were investigated thoroughly. Problems of design and quality control were uncovered and corrected.

DEFICIENCIES IN N2 GAS VALVE TRANSDUCERS - Malfunctions in gas valve transducers impaired ability to determine cold gas usage rate and reserve. Better potting techniques were developed improving accuracy of data furnished.

GAS JET ASSEMBLY SUSCEPTIBILITY TO VIBRATION - High amplitude - 800CPS vibration was evidenced on both telemetry and landline data. Shake table tests verified the susceptibility of the assembly to vibrations at this frequency. The fix consisted of electrically decoupling the gas valve so that the mechanical vibration could not be reflected through the circuitry and cause excessive gas loss.

HYDRAULIC PACKAGE FAILURE - During engine firing the hydraulic oil pressure oscillated peak-to-peak through a 1200 PSIG range. Several tests including both the flight vehicle and PTVA S/N 0006 hydraulic package were made using derated high pressure relief valves and the deliberate introduction of gas into the hydraulic oil.

HORIZON SENSOR MOUNTING BOLT PROBLEM - During the firing test one mounting nut on each horizon sensor head vibrated loose. Q.A.-verified procedural records assured that these bolts were properly torqued prior to the test. Improved securing methods were incorporated and verified on subsequent captive firings.

SIGNIFICANT FINDINGS

SUBSYSTEM C & C

A number of trouble and discrepant items of equipment have been found in the C & C area. A typical example was an oxidizer venturi inlet pressure transducer that ruptured during an engine firing. Oxidizer vapor was sprayed over the aft equipment area requiring replacement of several cables, switches, and transducers. As a result of this failure and detailed examination of the failed part, the qualification and test procedures for transducers have been strengthened to prevent a recurrence.

SANTA CRUZ TEST BASE
MISSION

1124

I. DEVELOPMENT TESTING

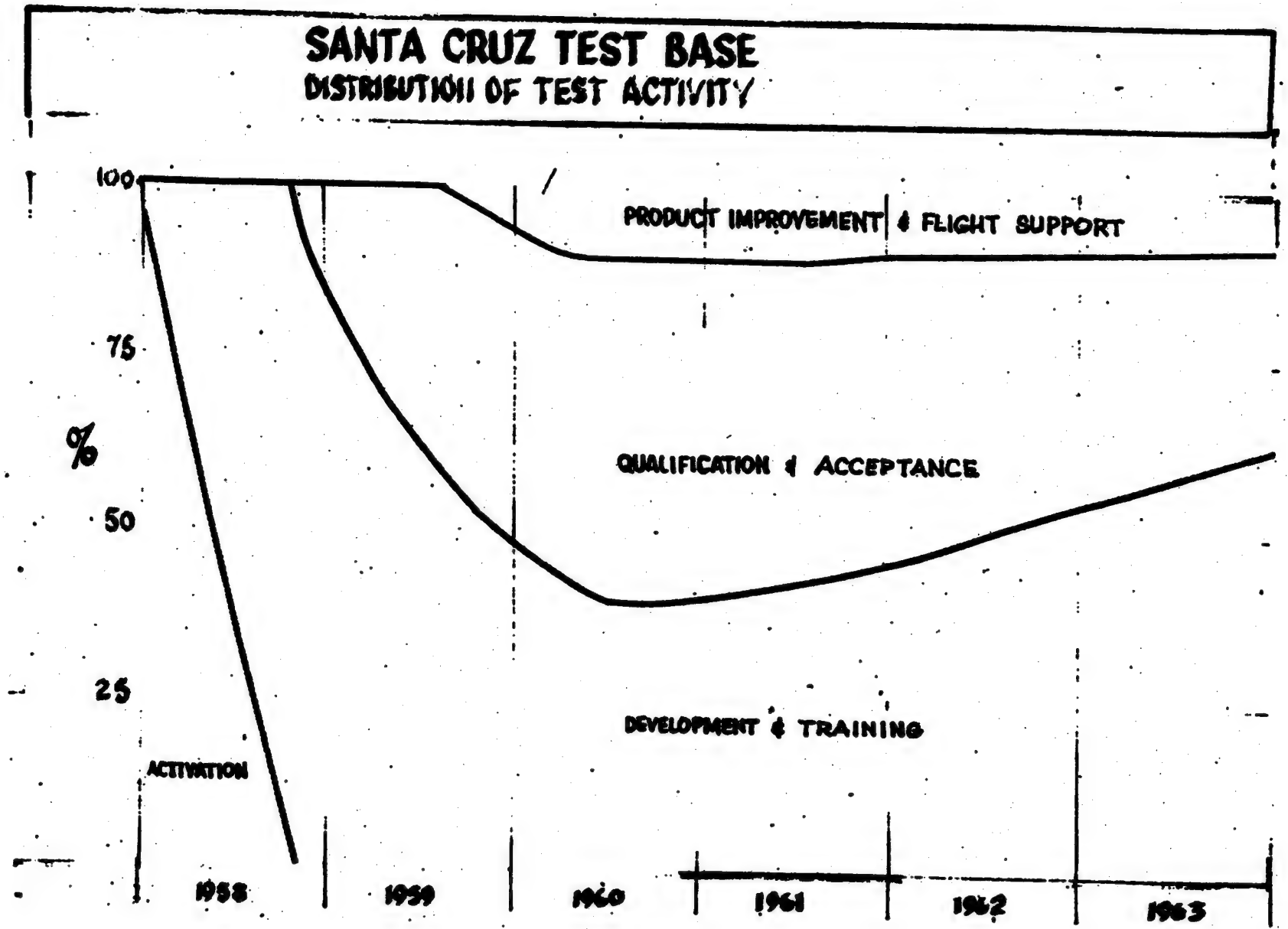
II. QUALIFICATION AND ACCEPTANCE TESTING

III. PRODUCT IMPROVEMENT SUPPORT

IV. FLIGHT FAILURE ANALYSIS SUPPORT

V. TRAINING

VI. SYSTEM TEST BACK-UP


SANTA CRUZ TEST BASE
DISTRIBUTION OF TEST ACTIVITY
100
75
%
50
25
PRODUCT IMPROVEMENT & FLIGHT SUPPORT
QUALIFICATION & ACCEPTANCE
DEVELOPMENT & TRAINING
ACTIVATION
1958
1959
1960
1961
1962
1963

SANTA CRUZ TEST BASE
RESOURCES FOR SPACE SYSTEMS PROGRAMS

- SPACE SYSTEMS TEST STAND COMPLEX
  - 2 TEST STANDS
  - 1 CONTROL BLOCKHOUSE
- MISSILE SYSTEMS TEST STAND COMPLEX
  - 1 TEST STAND
  - 1 CONTROL BLOCKHOUSE
- EMSC ORDNANCE
  - HIGH ENERGY TEST PAD & BLOCKHOUSE
  - ORDNANCE DEVELOPMENT LAB (3 TEST CELLS & ENVIRONMENTAL GENERATORS)
  - EXPLOSIVE STORAGE FACILITIES
- SPACE SYSTEMS COMPONENT TEST LAB
  - 3 TEST CELLS
  - CONTROL BLOCKHOUSE
- SUPPORT FACILITIES
  - MACHINE & FABRICATION SHOP
  - PHOTO LAB
  - CHEMICAL LAB
  - VALVE SHOP
  - INSTRUMENTATION & STANDARDS LABS

SANTA CRUZ TEST BASE
PAST & PRESENT ACTIVITIES

DEVELOPMENT TESTING

1. COMPATIBILITY TESTS OF ENGINE & OTHER PROPELLANT FEED SYSTEM FOR AGENA A/IRFNA/JP-4, AGENA A/IRFNA/UDMH, AGENA B, & AGENA D CONFIGURATIONS. 53 FIRINGS OF PTVA & DTV VEHICLES.
2. TEST OF VEHICLE SUBSYSTEMS IN ENGINE FIRING ENVIRONMENT.
3. COMPATIBILITY TEST OF SECONDARY/PRIMARY PROPULSION SYSTEM COMBINATION – 6 FIRINGS OF PTVA.
4. DEVELOPMENT TESTING OF PROPELLANT HANDLING, SERVICING & CONDITIONING EQUIPMENT FOR AGENA A & B.
5. DEVELOPMENT TESTING OF ALL AGENA PYROTECHNIC & DESTRUCT SYSTEM DEVICES – 6230 ORDNANCE TESTS.
6. DEVELOPMENT OF PROPULSION COMPONENTS & ACCESSORIES – 200 CTL FIRINGS.

SANTA CRUZ TEST BASE

PAST & PRESENT ACTIVITIES (CONTINUED - PAGE 2)

QUALIFICATION TESTING

1. PERFORM SIMULATED FLIGHT TESTS INCLUDING HOT-FIRING FOR 34 FLIGHT VEHICLES OF THE AGENA A AND AGENA B CONFIGURATION.

2. PERFORMED QUALIFICATION TESTING OF THE AGENA A AND AGENA B LAUNCH BASE PROPELLANT HANDLING, SERVICING AND CONDITIONING EQUIPMENT.

3. PERFORMED QUALIFICATION TESTING OF THE MAJORITY OF THE PYRO-TECHNIC AND EXPLOSIVE COMPONENTS. (8000 TESTS)

4. PERFORMED QUALIFICATION TESTING OF THE ORIFICE CONTROLLED PRESSURIZATION SYSTEM.

5. PERFORMED QUALIFICATION TESTING OF RECOVERY PACKAGE STRUCTURE.

6. PERFORMED 52 FILL AND DRAIN OPERATIONS

SANTA CRUZ TEST BASE

PAST AND PRESENT ACTIVITIES (CONTINUED PAGE 3)

PRODUCT IMPROVEMENT AND FLIGHT SUPPORT

1. DIAGNOSTIC TESTING TO IDENTIFY THE RECOVERY ATTITUDE CONTROL SYSTEM PROBLEM.

2. DEVELOPED AN IMPROVED ATTITUDE CONTROL SYSTEM EMPLOYING A COLD GAS SYSTEM.

3. DIAGNOSTIC TESTING OF THE HYDRAULIC PACKAGE.

4. DETERMINED INABILITY OF ALUMINUM WIRING TO WITHSTAND ENGINE FIRING VIBRATION.

5. PRODUCT IMPROVEMENT BY IDENTIFICATION OF PROBLEMS INVOLVING PROPELLANT ISOLATION VALVE, ENCAPSULATED FUSISTORS, GUIDANCE AMPLIFIER INSTABILITY.

6. TRAINED LAUNCH BASE CREWS IN SERVICING AND OPERATING, PRIMARY AND SECONDARY SYSTEMS, PAYLOADS AND PROPELLANT SERVICING EQUIPMENT.

SANTA CRUZ TEST BASE
FUTURE

DEVELOPMENT TESTING

1. GEMINI PTVA - DEVELOP A MULTIPLE START PROPULSION SYSTEM & IMPROVED SECONDARY PROPULSION SYSTEM.
2. GEMINI DTV - DEVELOP IN-SPACE REFUELING TECHNIQUES.
3. ORDNANCE DEVICES - CONTINUED DEVELOPMENT AS REQUIRED BY PROGRAMS.
4. MIST - SPECTRAL TEST FOR 239A.
5. PROPOSED 239A PTVA
   - A. EVALUATE THE LONG TERM EFFECT OF RESIDUAL PROPELLANTS EXPOSURE TO THE PROPULSION SYSTEM.
   - B. DETERMINE RESULTING SYSTEM PERFORMANCE.
   - C. DEVELOP SERVICING TECHNIQUES REQUIRED TO MAINTAIN SYSTEM PERFORMANCE.

QUALIFICATION TESTING

1. FLIGHT VEHICLES - SIMULATED FLIGHT INCLUDING HOT-FIRING OF 6 MMSA FLIGHT VEHICLES INCLUDING ONE GEMINI VEHICLE.
2. COMPONENTS & EQUIPMENT - QUALIFICATION OF ORBITAL DOCKING.
3. ORDNANCE DEVICES - QUALIFICATION OF PYROTECHNIC & EXPLOSIVE DEVICES.

PRODUCT IMPROVEMENT & FLIGHT SUPPORT

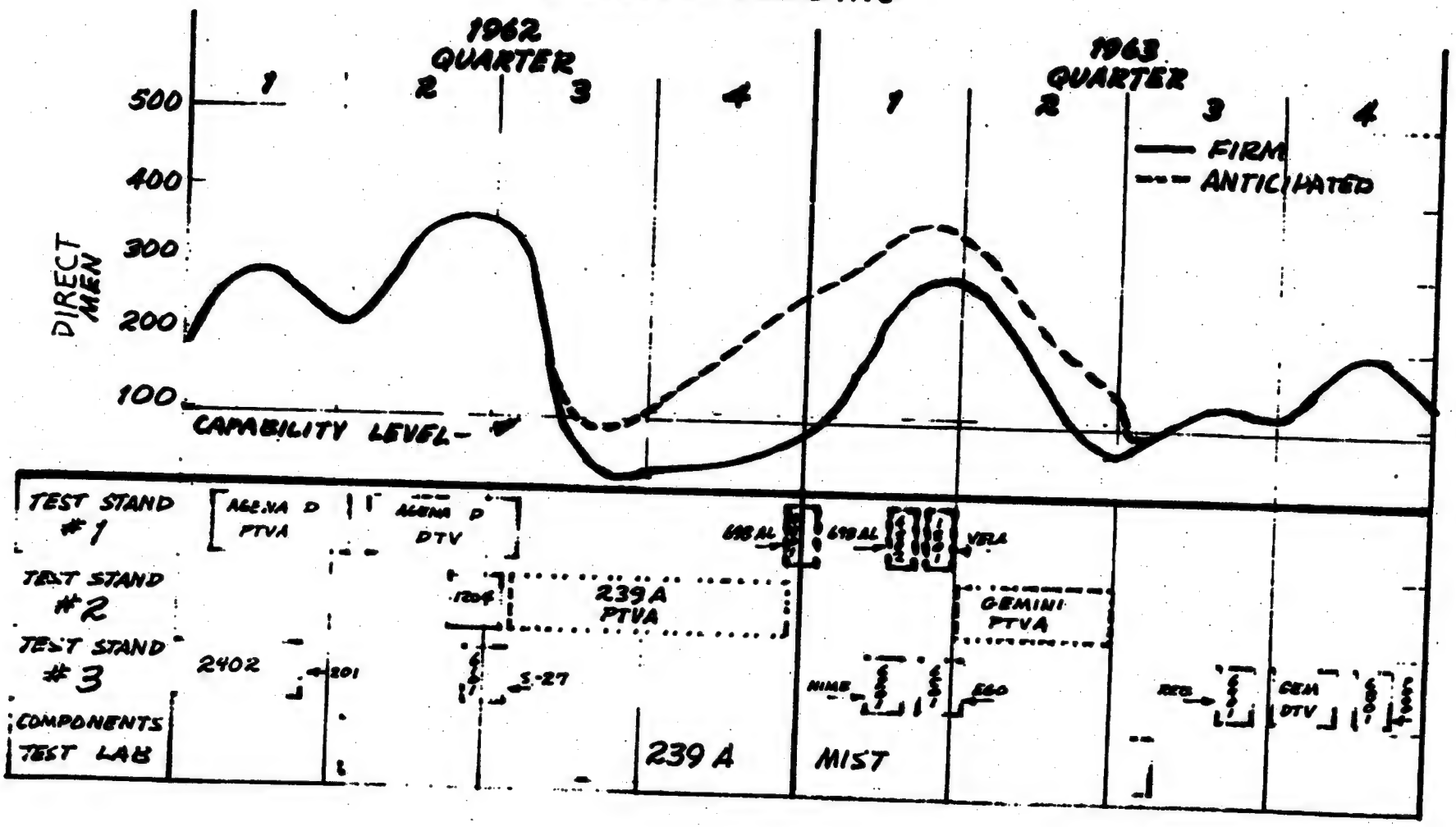
PAST EXPERIENCE INDICATES THAT SUPPORT WILL BE REQUIRED FOR AGENA D CONFIGURATIONS.

SYSTEM TEST BACKUP

ALTERNATE FACILITIES FOR SYSTEMS TEST OF 698AL & 698AM.

SPACE SYSTEMS SANTA CRUZ TEST

FACILITY LOADING



SANTA CRUZ TEST BASE
COST SOURCES

PROGRAM SUPPORT EFFORT SPECIFIC TEST PREPARATION, PROCEDURES, TEST OPERATIONS, AGE. DESIGN, DATA PROCESSING, ANALYSIS AND REPORTING.	ACCOUNTING METHOD REQUESTING PROGRAM
SUSTAINING EFFORT EQUIPMENT PREVENTIVE MAINTENANCE, FACILITY AND EQUIPMENT UPDATING, MAINTENANCE OF PERSONNEL TECHNICAL COMPETENCE IN OPERATION OF FACILITY	ALL PROGRAMS INVOLVING LAUNCH VEHICLES
MANAGEMENT, SUPERVISORY, CLERICAL	ALL PROGRAMS INVOLVING LAUNCH VEHICLES

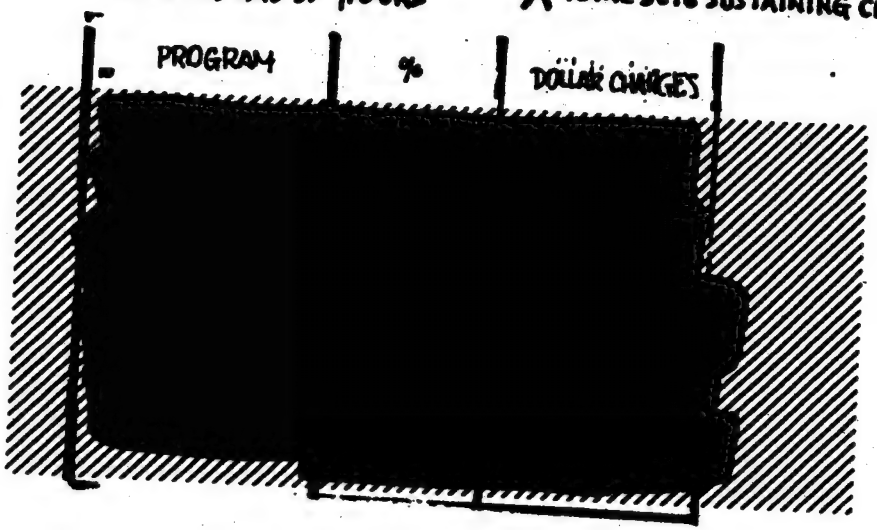
SANTA CRUZ TEST BASE
FUTURE

SUSTAINING COSTS

IT IS ESTIMATED THAT 84 PEOPLE ARE REQUIRED TO MAINTAIN THE RECOMMENDED RESOURCES. AND IT IS ASSUMED THAT NO MORE THAN AN AVERAGE OF 55 WILL BE CHARGING THE SUSTAINING ACCOUNT. EXTENDED OVER THE NEXT YEAR IT IS ESTIMATED THAT THE PROGRAMS LISTED BELOW WILL BE CHARGED AS SHOWN.

CHARGES WILL BE APPORTIONED TO THE PROGRAMS UTILIZING THE FOLLOWING FORMULA.

$$\frac{\text{TOTAL INDIVIDUAL PROGRAM HOURS}}{\text{TOTAL SSD AND SP HOURS}} \times \text{TOTAL SCTB SUSTAINING CHARGES} = \text{SCTB SUSTAINING CHARGE}$$



SANTA CRUZ TEST BASE
CONCLUSIONS AND RECOMMENDATIONS

1. TEST BASE STILL REQUIRED IN R+D PROGRAMS-
   ALL PROGRAMS WILL BENEFIT

THEREFORE-

2. RETAIN ALL EXISTING FACILITIES IN AN OPERATIONAL STATUS THROUGH CY 1963. (WITH LIMITATIONS)

3. CONTINUE TO UTILIZE EXISTING ACCOUNTING METHOD TO
   A) ACCUMULATE OPERATING COSTS TO REQUESTING PROGRAMS.

   B) ACCUMULATE SUSTAINING COSTS AND DISTRIBUTE TO ALL BENEFITING PROGRAMS.

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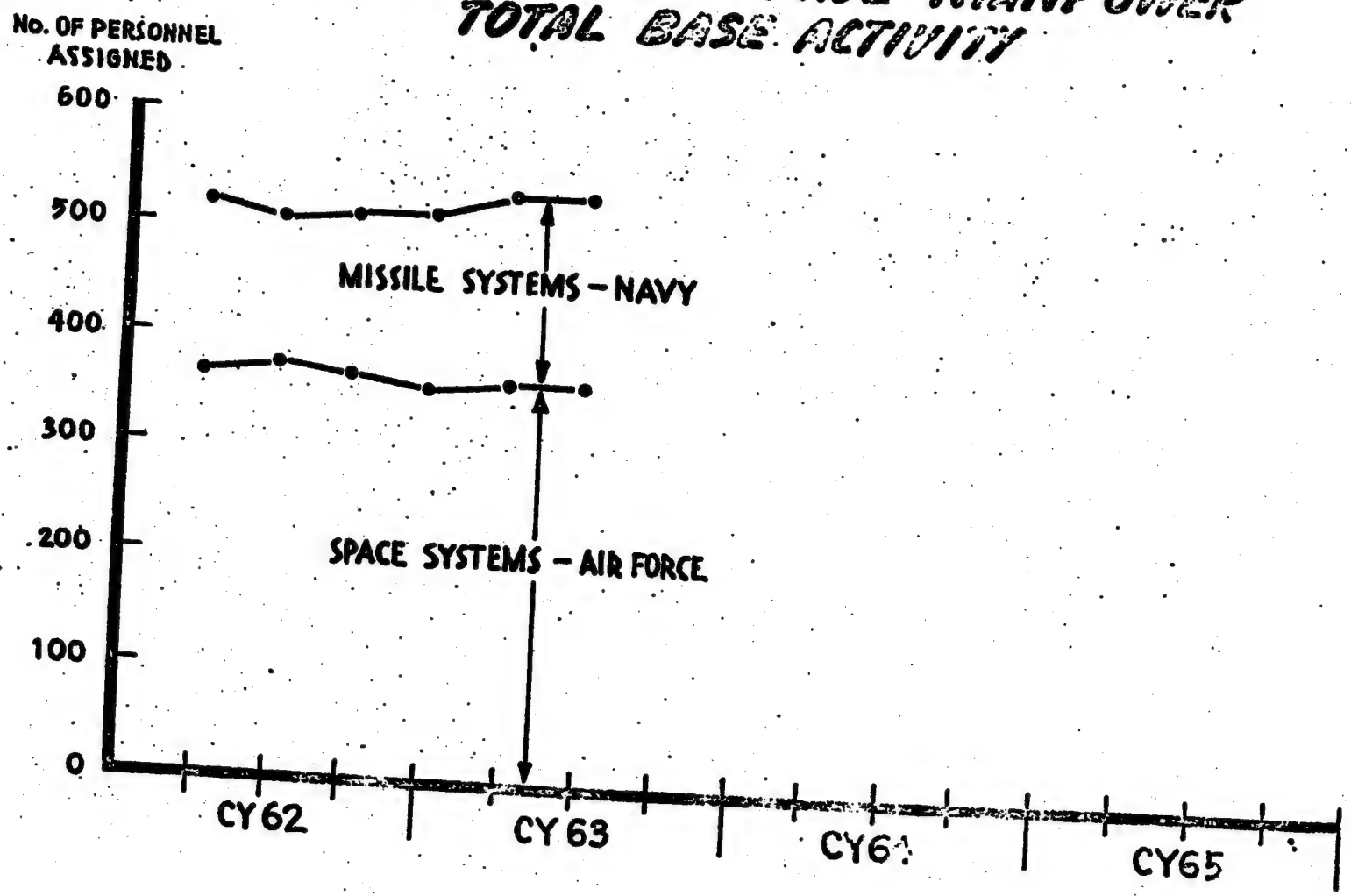
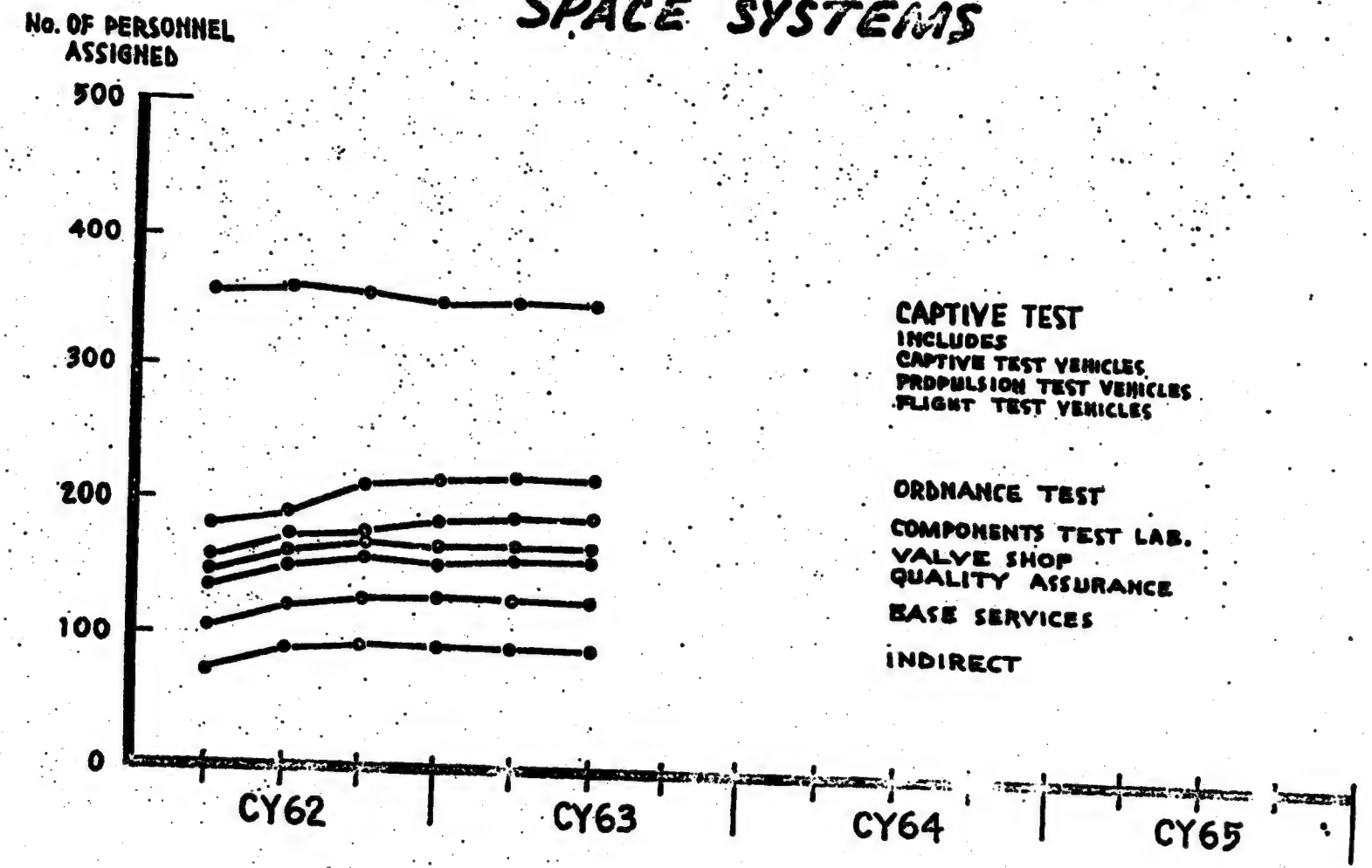
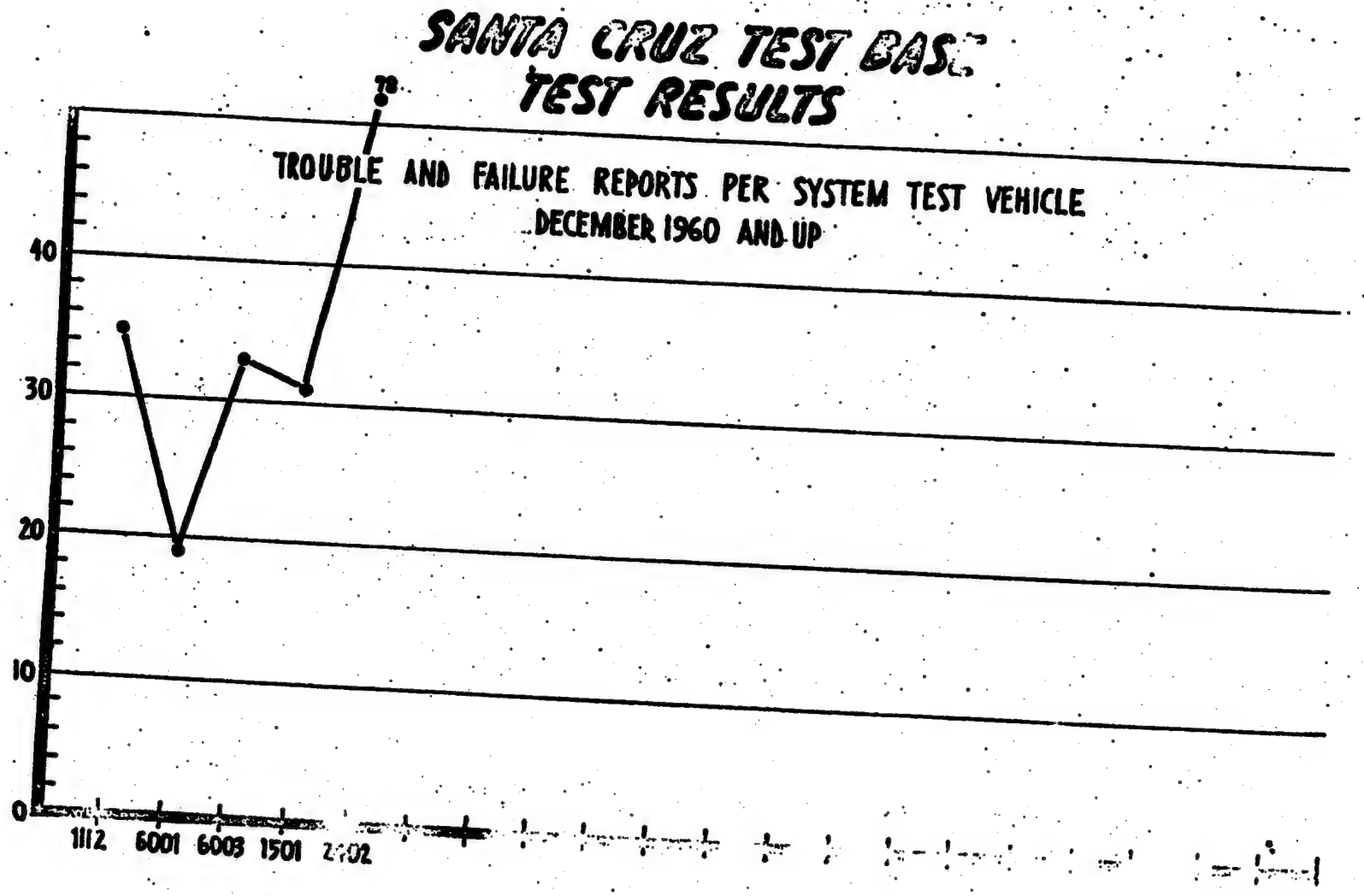
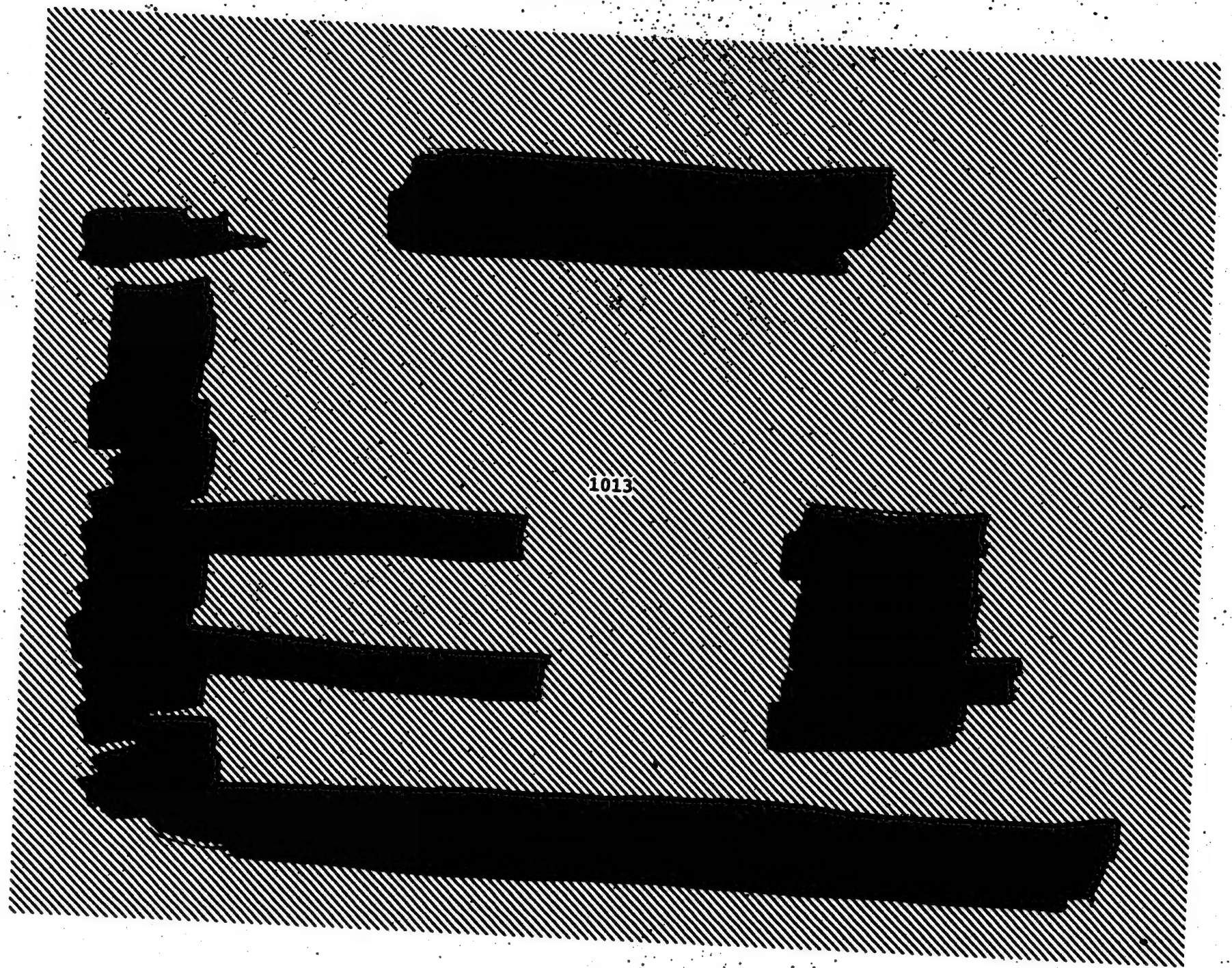
SANTA CRUZ TEST BASE MANPOWER
TOTAL BASE ACTIVITY



SANTA CRUZ TEST BASE MANPOWER
SPACE SYSTEMS




SANTA CRUZ TEST BASE
TEST RESULTS
TROUBLE AND FAILURE REPORTS PER SYSTEM TEST VEHICLE
DECEMBER 1960 AND UP
40
30
20
10
0
1112
6001
6003
1501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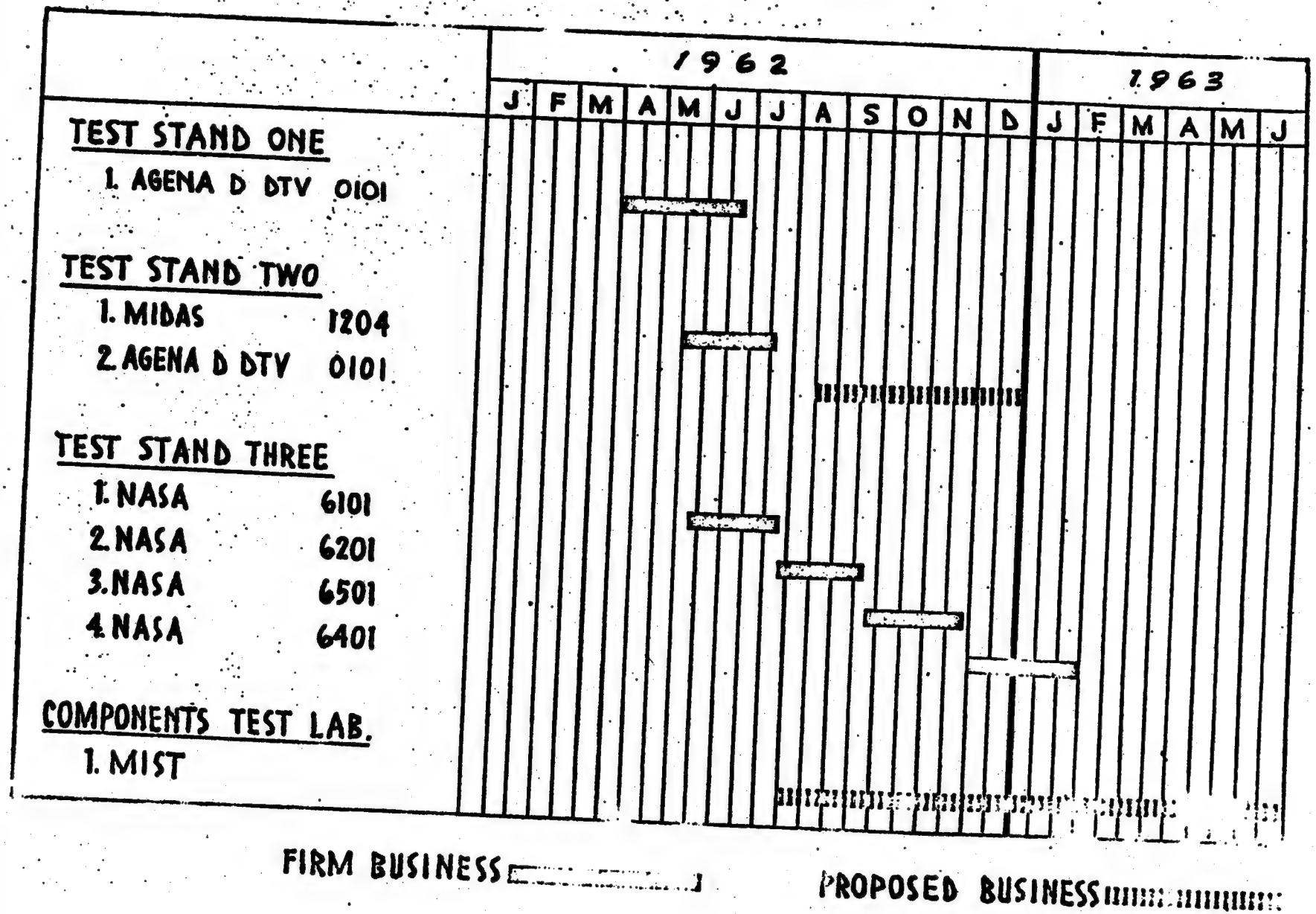
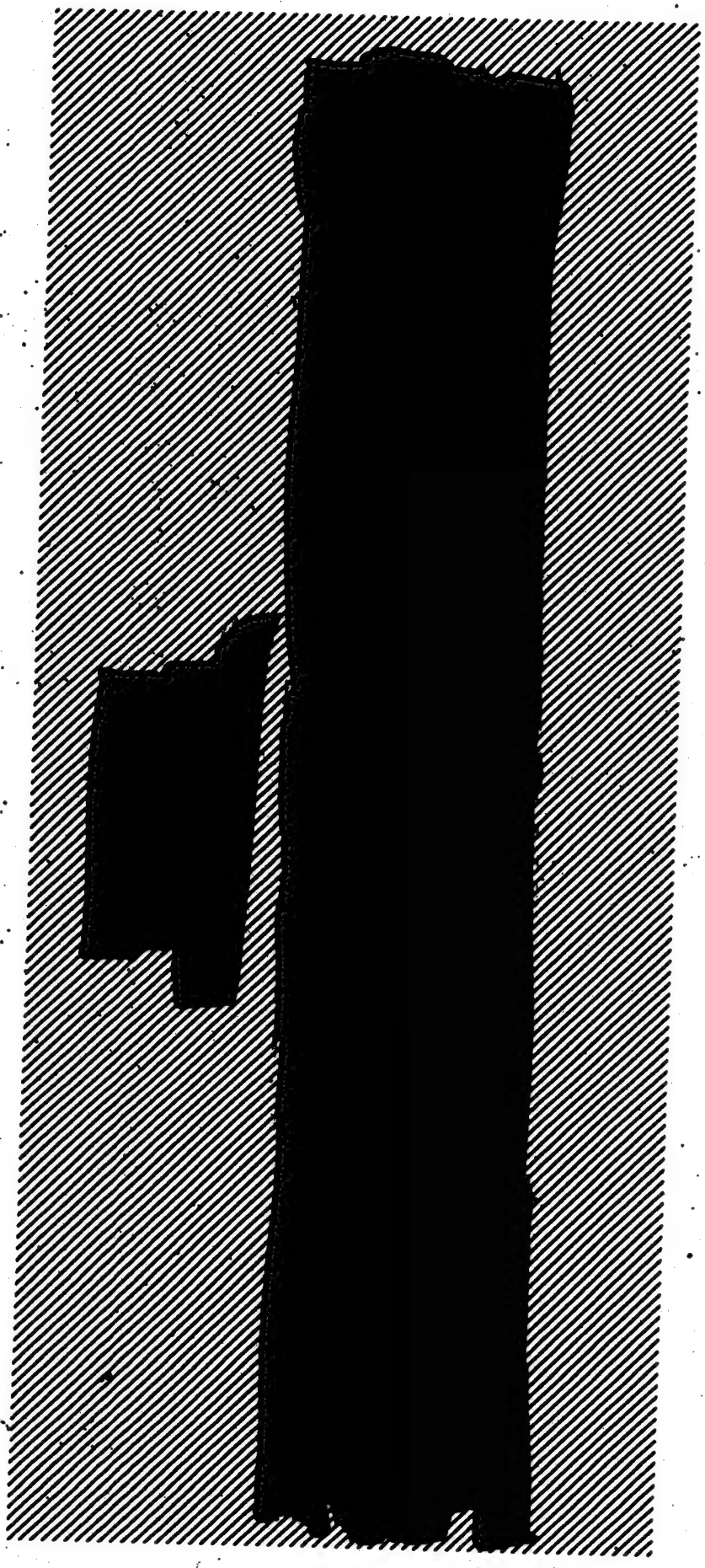
SPACE SYSTEMS SANTA CRUZ TEST
TEST STAND LOADING



SANTA CRUZ TEST BASE
MANPOWER DISTRIBUTION

FUNCTION	1Q62	2Q62	3Q62	4Q62	1Q63	2Q63
Captive Test	173	161	141	131	131	131
Ord. Test	31	32	34	35	35	35
Comp. Test	5	5	10	20	20	20
Valve Shop	9	9	9	9	9	9
GSE Lab	-	-	-	-	-	-
Q.A.	31	26	31	27	28	28
Base Services	32	35	37	38	38	38
Indirect	72	90	91	91	91	91
TOTAL SSD	353	358	353	351	352	352
% TOTAL	67	70	69	68	67	67
TOTAL NAVY	170	152	160	168	174	174
% TOTAL	33	30	31	32	33	33
GRAND TOTAL	523	510	513	519	526	526



B R I E F I N G

O N

S A N T A C R U Z T E S T B A S E

WDZYA
Agena Division
Hq AFSWD (ARDC)

17 JAN 1961

SANTA CRUZ TEST BASE

The following briefing has been assembled in support of the operation by Lockheed Missiles and Space Division of their Santa Cruz Test Base.

Its presentation is in response to a request by the Under Secretary of the Air Force, Dr Joseph Charyk, as referenced in his memorandum to the Chief of Staff.

Our basic conclusion is that the test base should be continued in operation in support of the Satellite Systems Programs being pursued and supported by Lockheed. The data and results produced at Santa Cruz have been of significant value to the Development and Flight Test Program to date, and are determined to be of a continuing and important nature in the future.

WDZ

SANTA CRUZ TEST BASE
LOCKHEED MISSILES AND SPACE DIVISION

I REQUIREMENTS

II DESCRIPTION OF BASE AND FACILITIES

III INVESTMENT

IV MANPOWER

V OPERATIONS AND TEST RESULTS

VI WORKLOAD

VII COST OF OPERATIONS

SANTA CRUZ TEST BASE

- REQUIREMENTS

  RESEARCH, DEVELOPMENT AND TEST

  - FLIGHT VEHICLE ORDNANCE COMPONENTS
  - PROPULSION SYSTEMS COMPONENTS
  - COMPLETE PROPULSION SYSTEMS
  - COMPLETE FLIGHT VEHICLES
  - GROUND SUPPORT EQUIPMENT
  - HANDLING, SERVICE AND CHECKOUT PROCEDURES

  PROVIDE

  TRAINING FOR AIR FORCE PERSONNEL

  ASSISTANCE AT LAUNCH BASES

  REMOTE SITE FOR HAZARDOUS TESTING

REQUIREMENTS - RESEARCH, DEVELOPMENT AND TEST

FLIGHT VEHICLE ORDNANCE COMPONENTS - Destruct devices, pyrotechnic valves, guillotines, squib actuated pin pullers and pin pushers, ullage rockets, retro rockets, separation devices, etc.

PROPULSION SYSTEM COMPONENTS - Valves, pressurization systems, nozzle extensions, hydraulic pumps and actuating cylinders, vent tank nullifiers, etc.

COMPLETE PROPULSION SYSTEMS - As assembled in a Propulsion Vehicle Test Assembly consisting of AGENA tanks, the BELL Model 8096 (XLR81-BA-9) engine, the pressurization, feed and load system, guidance and auxiliary power components, forward and aft racks, etc.

COMPLETE FLIGHT VEHICLES - Delivered to the Santa Cruz Test Base for hot firing under simulated flight conditions to verify the capability of a complete vehicle system to perform its required operations. This is in a sense a production test operation now being performed on a modified sampling basis under the new test philosophy. This philosophy requires that the first vehicle of a new or different block, ie, configuration be hot fired as a complete flight vehicle. Pending results, the next vehicle to be fired of a block is the fourth.

HANDLING, SERVICING AND CHECKOUT PROCEDURES - These are developed, tried out and refined at Santa Cruz Test Base under actual operating conditions.

TRAINING FOR AIR FORCE PERSONNEL - Provided on the site with actual equipment under nearly actual operating conditions. Capability relieves load at launch bases and avoids duplication of equipment. Pad time is necessarily limited.

ASSISTANCE AT LAUNCH BASES - Trained experts from the Santa Cruz Test Base are always available to lend a hand.

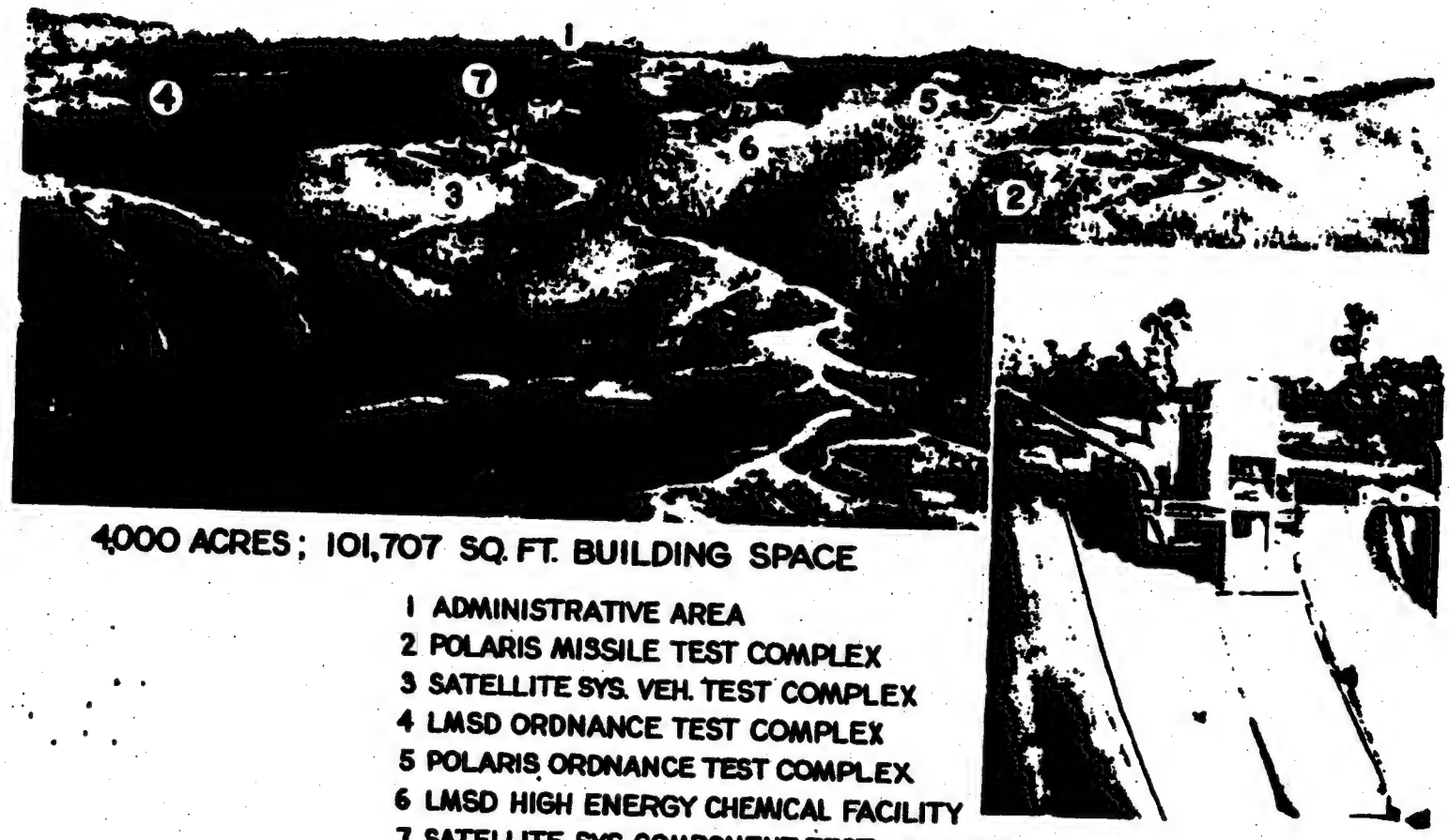
LMSD FACILITIES - SANTA CRUZ

Proof testing of the many elements of the weapon or space systems ultimately requires tests of the integrated system under actual firing conditions. LMSD established such testing facilities on a 4,000 acre tract in the mountains near Santa Cruz, California, 35 miles from its Sunnyvale headquarters. Separate facilities are provided for the Agena satellites and Polaris missiles. In addition, other areas have been developed for development and testing of ordnance or explosive devices and high energy chemical mixing.

All Polaris test facilities are completely Navy owned and are situated on 271 acres of land which was deeded to the Navy by LMSD.

The natural topography of the test site, with its heavily wooded slopes, deep ravines and orientation on the ocean side of the slope provides a maximum of noise abatement, hazard protection and isolation. Ownership of surrounding property is mainly in large parcels by lumbering and cement insterests and by the State of California. This, in addition to the general unsuitability of the terrain for home sites, increases its isolation. The lake provides an abundant source of water for all purposes.

LMSD FACILITIES - SANTA CRUZ



4,000 ACRES; 101,707 SQ. FT. BUILDING SPACE

1 ADMINISTRATIVE AREA
2 POLARIS MISSILE TEST COMPLEX
3 SATELLITE SYS. VEH. TEST COMPLEX
4 LMSD ORDNANCE TEST COMPLEX
5 POLARIS ORDNANCE TEST COMPLEX
6 LMSD HIGH ENERGY CHEMICAL FACILITY
7 SATELLITE SYS. COMPONENT TEST LABORATORY

SCTB MAJOR TEST FACILITIES

There are three test stands with instrumentation and control blockhouses at SCTB for captive firing of complete Polaris missiles and Agena satellites. These stands permit a degree of movement in the stand during the test run and are known as "dynamic restraint" stands. Variations in thrust, effectiveness of control systems and affect of vibration upon systems can be determined. Insofar as is known, the dynamic restraints are unique in the United States. The Polaris stand is currently being modified under NASA funding to permit testing of satellite vehicles as well as Polaris missiles.

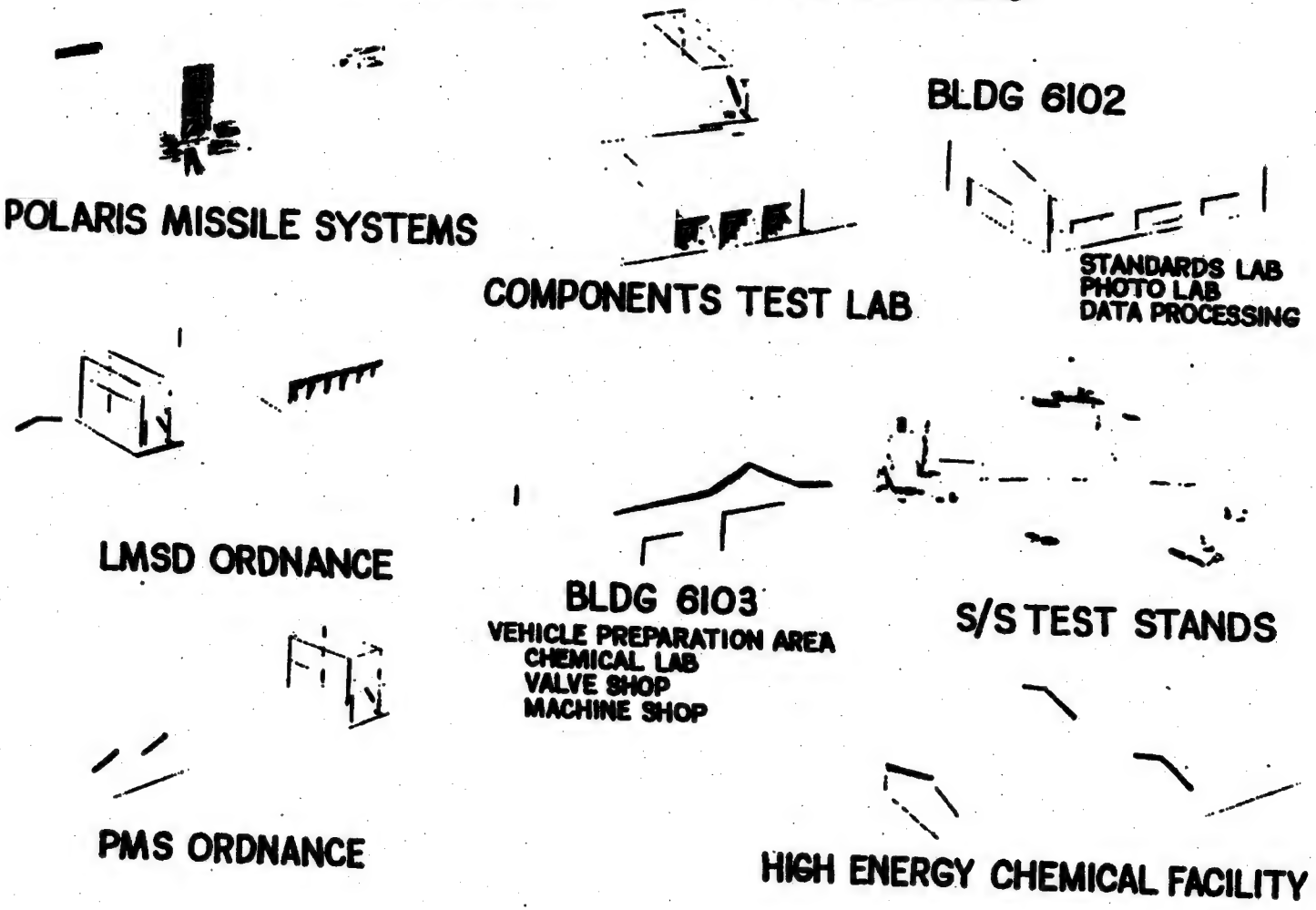
In addition to its stands, the Navy's Polaris program has recently completed an ordnance test area consisting of firing pad, blockhouse, laboratories and magazines. This augments an ordnance test area which was previously constructed by Lockheed. Equipment is provided in these two facilities for testing squib-actuated and other ordnance type devices under environmental conditions such as vibration and simulated high altitude.

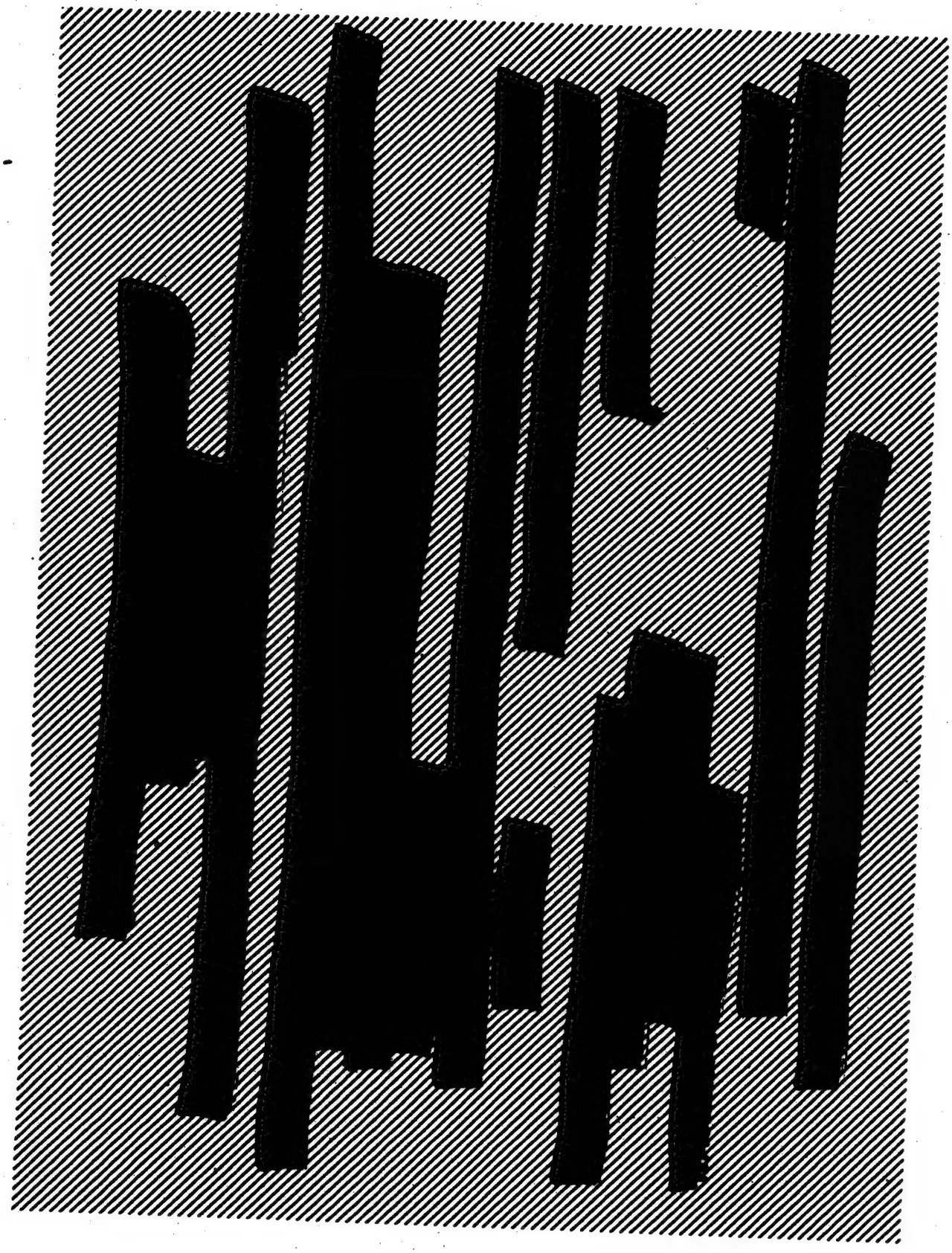
Satellite Systems staffs the operation of a Components Test Laboratory, a valve shop and ground support equipment test area. Activities in support of vehicle manufacture test and launch operations are carried on here. Test and development work in these areas include pressurization systems and devices, materials compatibility studies, fueling and other ground handling equipment, umbilical connectors, etc.

A recent addition has been a High-Energy Chemical facility. Here LMSD research personnel experiment with the mixing and firing of new higher energy chemicals for possible propellant uses.

Other operations conducted by LMSD personnel which are partially supported by Satellite Systems consist of a chemical laboratory for fuel and other material analysis, still and motion picture photo laboratories, Measurement Standards Laboratory, machine Shop and other support functions.

SCTB MAJOR TEST FACILITIES





SANTA CRUZ TEST BASE

MANPOWER

The two following charts present historical data on manpower assigned at the Santa Cruz Test Base and a projection of manpower requirements thru June 1962.

Manpower levels shown are contracted for through March 1961. Contracts covering the future period for Satellite Systems support (the Air Force portion) are under negotiation.

Tabular data is also presented following the two charts.

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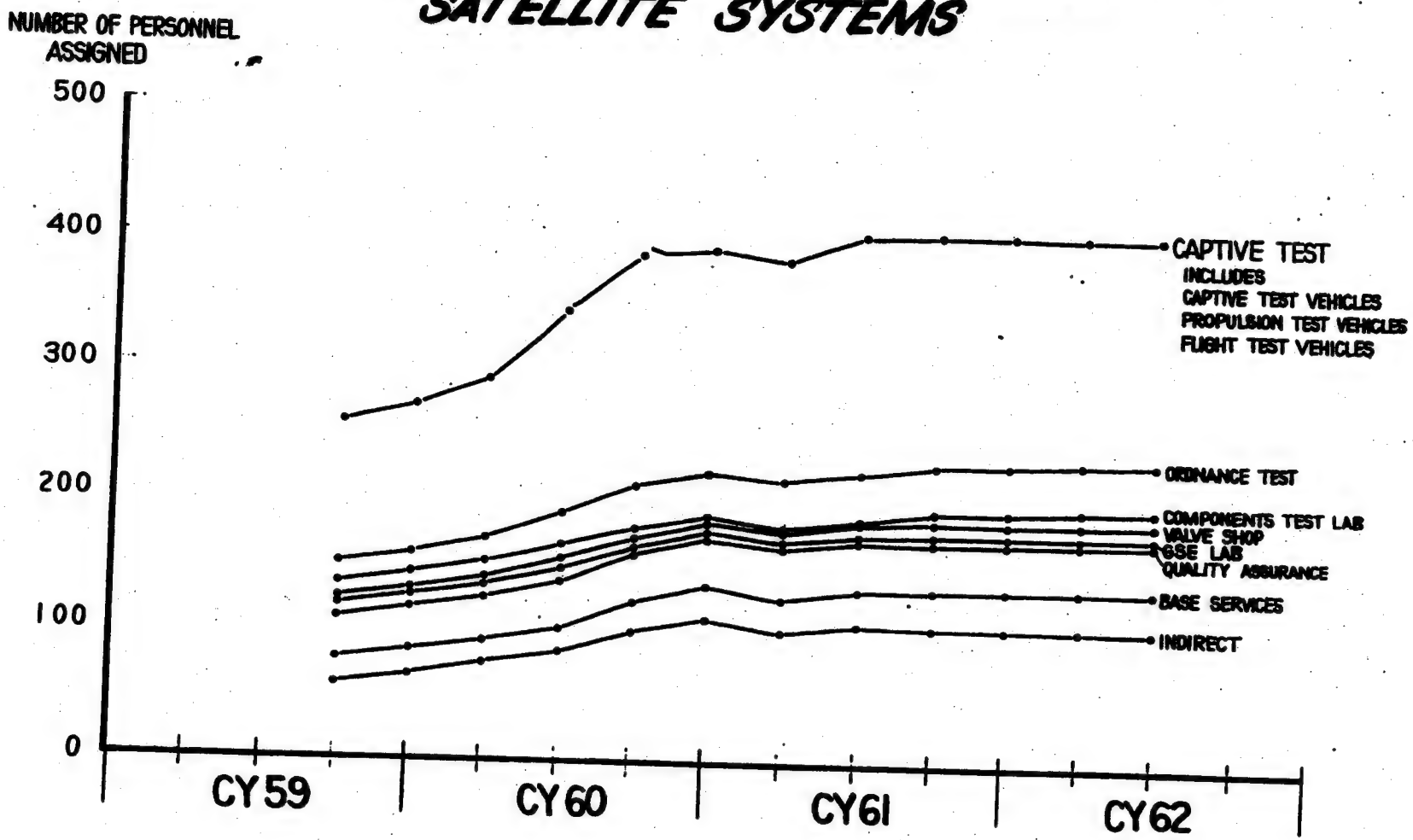
SANTA CRUZ TEST BASE MANPOWER
SATELLITE SYSTEMS



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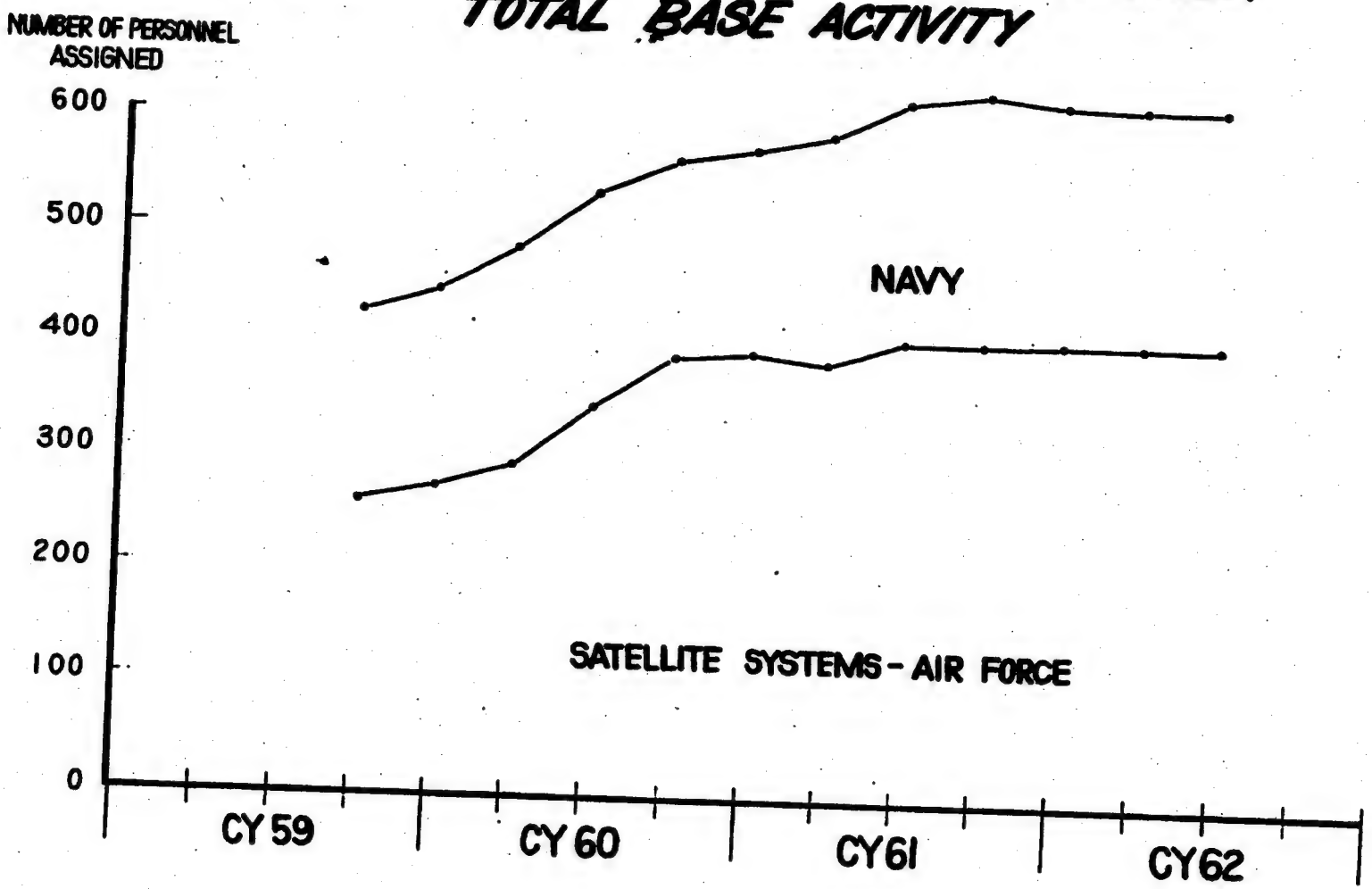
SANTA CRUZ TEST BASE MANPOWER
TOTAL BASE ACTIVITY



SANTA CRUZ TEST BASE

MANPOWER DISTRIBUTION

FUNCTION	3959	4959	1960	2960	3960	4960	1961	2961	3961	4961	1962	2962
CAPTIVE TEST	108	114	123	154	180	173	172	182	176	176	174	174
CRD TEST	16	16	18	26	30	32	33	34	35	35	35	35
COMP TEST	10	12	12	10	8	4	4	4	8	8	10	10
VALVE SHOP	5	5	6	6	7	8	8	8	10	10	10	10
GSE LAB	10	10	10	10	8	6	6	6	6	6	6	6
Q/A	31	31	31	34	36	36	37	37	37	37	37	37
BASE SERV	19	19	17	20	23	26	27	28	29	30	30	30
INDIRECT	58	65	75	34	99	109	100	105	104	104	104	104
TOTAL S/S	257	272	292	344	389	394	387	404	405	406	406	406
% TOTAL	60.6	61.3	60.2	64.2	68.9	68.4	65.6	65.3	64.4	64.2	65.6	65.6
TOTAL NAVY	167	172	193	192	176	182	203	215	224	226	213	213
% TOTAL	39.4	38.7	39.8	35.8	31.1	31.6	34.4	34.7	35.6	35.8	34.4	34.4
GRAND TOTAL	424	444	485	536	565	576	590	619	629	632	619	619

TYPICAL SCTB FIRING OPERATION

A typical SCTB firing operation can be briefly described as a captive flight test. It is a complete systems test in the true sense of the word. In addition, it is a captive flight test in the sense that a deliberate attempt is made to simulate actual conditions as closely as possible.

The chart shows the correlation between selected events occuring during a typical vehicle flight and the corresponding SCTB simulation. Many of the test events are identical to those occuring in flight.

During an SCTB firing operation, all onboard vehicle subsystems are exercised. Landline instrumentation, suitably isolated, is utilized to the maximum to augment and verify the data recorded by RF radiation through the vehicle telemetry systems.

The center section of the chart, labeled SCTB and Flight, contains those functions that are common between the two. Other flight operations are listed at the bottom of the chart—the corresponding SCTB operations are listed on the top part.

TYPICAL SCTB FIRING OPERATIONS

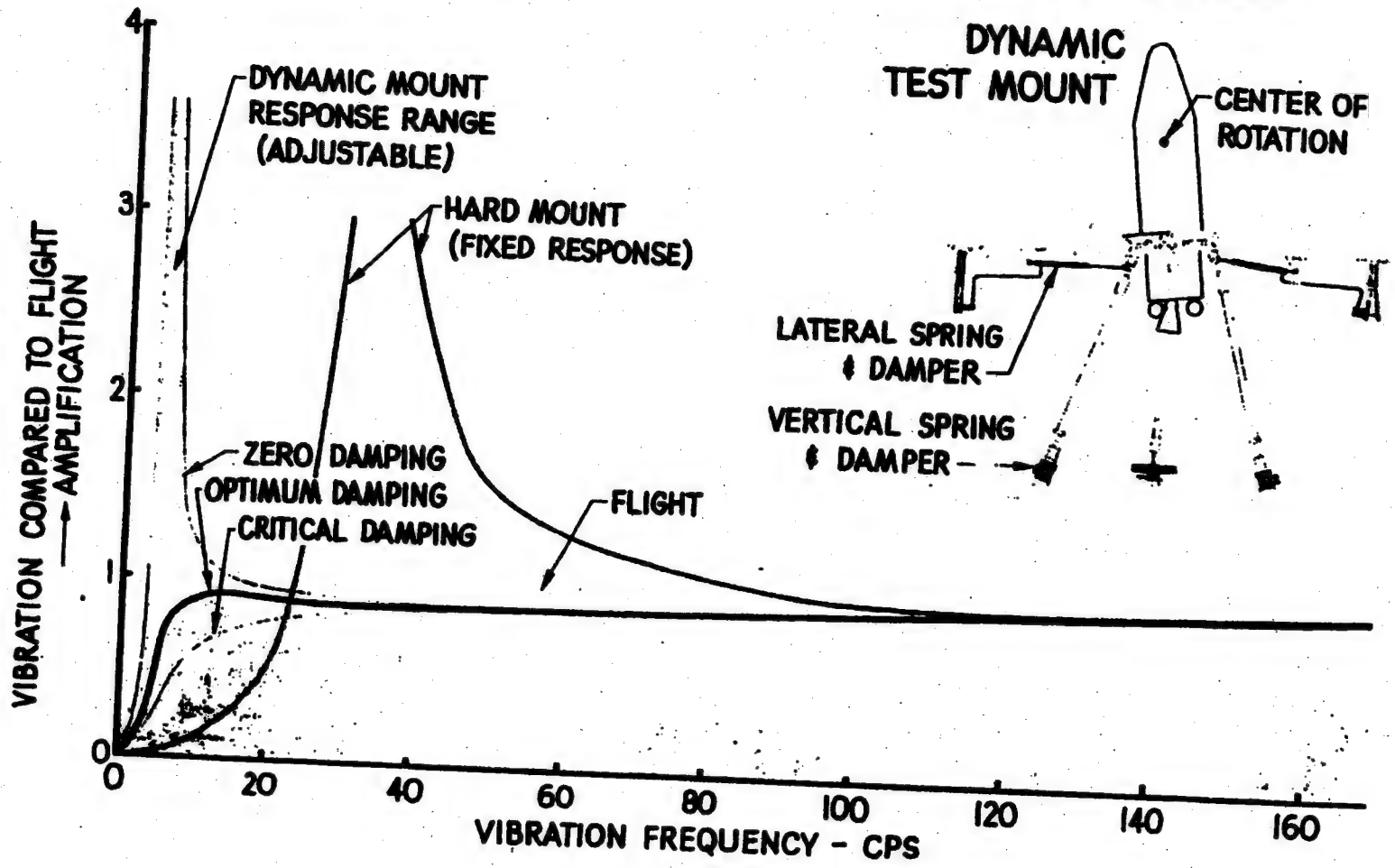
	BOOSTER BURN	1ST COAST	1ST AGENA BURN	2ND COAST	2ND AGENA BURN	ORBIT
SCTB	• LANDLINE INSTRUMENTATION TURNED ON • FINAL VEHICLE & FACILITY CHECKS • T/M ON • TERMINAL COUNTDOWN	• 'D' TIMER SIGNALS MONITORED	• GAS JET & THRUST CHAMBER GIMBALING PROGRAMMED	• GAS JET PROGRAMMED	• GAS JET & THRUST CHAMBER GIMBALING PROGRAMMED	• SIMULATE SUCCESSIVE ORBITS BY TIME COMPRESSION & SIMUL. OF NOMINAL ORBIT EVENTS THROUGH 3 SIMUL. ORBITS • LODAP OPERATION INCL. REDUNDANT SYSTEM • PAM ON - OPERATE REDUNDANT SYSTEM • MONITOR ALL 'D' TIMER EVENT SIGNALS
SCTB & FLIGHT	• VEHICLE POWER PREVIOUSLY TURNED ON	• PNEUMATICS ACTIVATED • LODAP TURNED ON • 'D' TIMER STARTS	• 'D' TIMER FIRES AGENA ENGINE • VELOCITY METER ARMED	• ALL 'D' TIMER SIGNALS MONITORED	• VELOCITY METER SHUTS DOWN ENGINE • 'D' TIMER FIRES AGENA ENGINE	• OPERATE AIRBORNE TAPE RECORDERS • PAYLOAD OPERATION • 'D' TIMER OFF
FLIGHT	• LIFT OFF • BOOSTER CUT OFF • SUSTAINER BURN • SUSTAINER CUT OFF • VERNIER CUT OFF • SEPARATION		• GAS JET ROLL CONTROL • THRUST CHAMBER GIMBALING	• GAS JET ATTITUDE CONTROL	• GAS JET ROLL CONTROL • THRUST CHAMBER GIMBALING	• 'D' TIMER EVENTS • PAM ON • LODAP OPERATION • SUCCESSIVE ORBITS

DYNAMIC MOUNT CHARACTERISTICS

The dynamic mounts in the Santa Cruz Test Stands constrains the vehicle in a manner to best simulate the vibrational environment of flight. The mount includes provisions for precision measurement of weight and thrust reactions. In addition, the mount is articulated to allow the vehicle to move in pitch and yaw under the influence of guidance controls, as desired.

The dynamic characteristics of the mount are fully determinant and remotely adjustable over a wide range, as indicated on the chart, to meet individual vehicle requirements. The primary longitudinal vibration frequencies of the Agena vehicles ranges from 30 to 90 cps. In this frequency range vehicle vibrations while on the dynamic mount will be close to those of flight. As can be seen on the chart, vehicle vibrations may be greatly amplified if tested on a rigid mount with small damping.

DYNAMIC TEST MOUNT CHARACTERISTICS



VIBRATION ANALYSIS

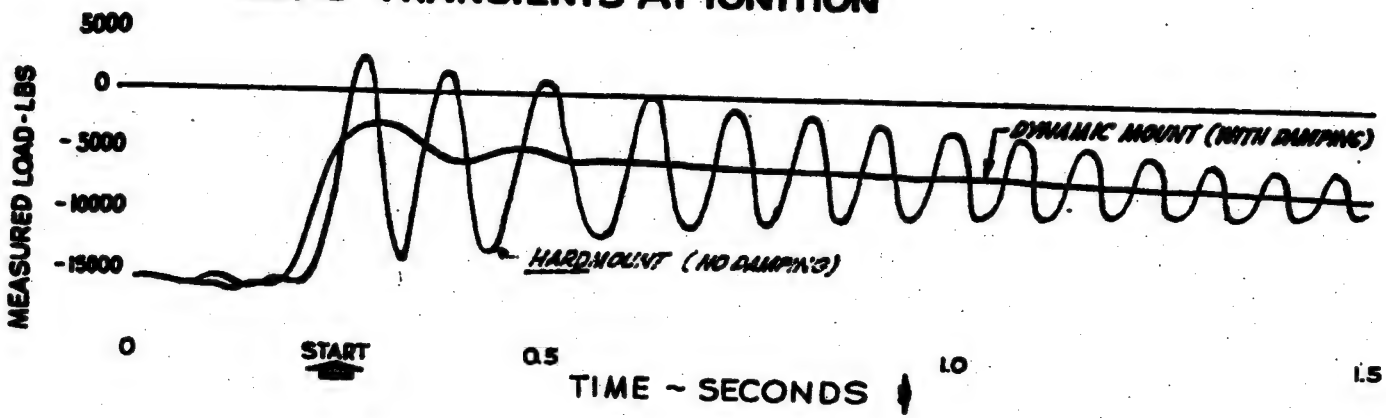
Comparisons of peak vehicle vibrations (g's) taken from both flight and captive tests on a dynamic mount, have been made for Atlas-Agena and Thor-Agena flights. Instances where there has been greatest disparity between flight and captive test vibrations are presented on the chart in order to indicate that discrepancies in vibration simulation are of low magnitude.

Although occuring at different phases of vehicle flight operation, the acoustic environment of the vehicle during captive test firings is approximately the same as encountered by the vehicle during launch and boost phases.

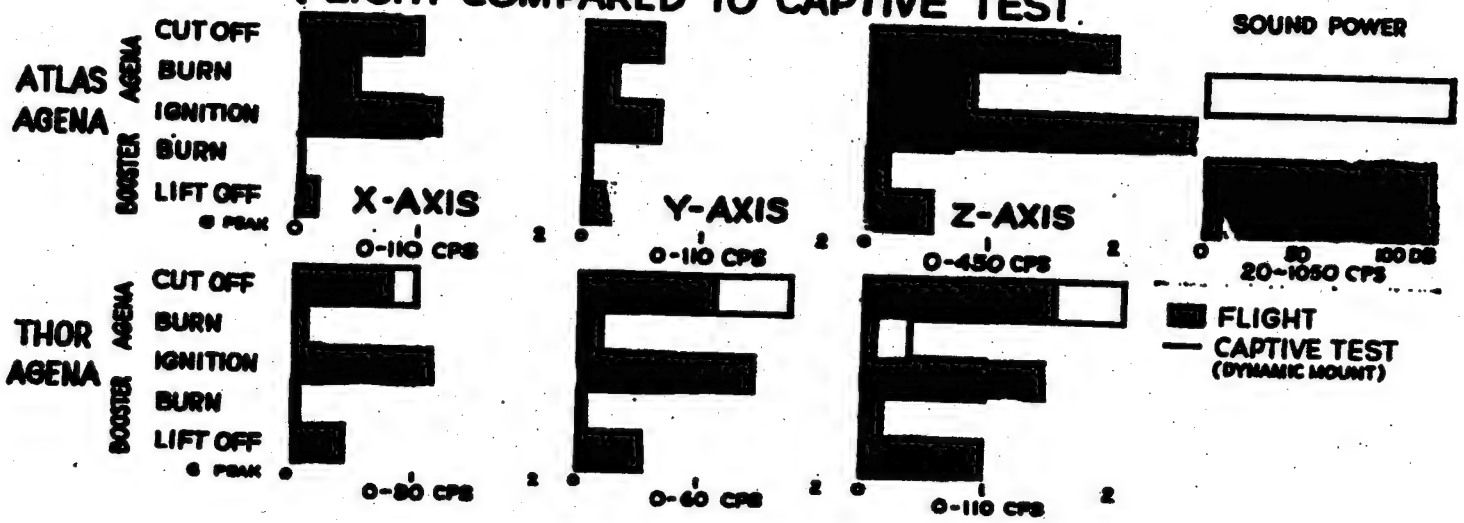
The strongest shock transient in captive testing occurs at main Agena engine start and cutoff. With the damping provided by the dynamic mount, there is little overshoot of forces. Data taken under equivalent conditions with the vehicle on a rigid mount, which by nature is undamped, indicates repeated force overshoots with abnormal aft accelerations.

SHOCK & VIBRATION ANALYSIS

LOAD TRANSIENTS AT IGNITION



FLIGHT COMPARED TO CAPTIVE TEST



SANTA CRUZ TEST BASE OPERATIONS

SIGNIFICANT FINDINGS

- SUBSYSTEM A-
  - STEEL SEALS SUBSTITUTED FOR ALUMINUM SEALS
  - TURBINE EXHAUST STACK MOUNTING BRACKET - MARGINAL
  - SEPARATION MONITOR NOISE
  - TANK SEAL DETERIORATION PROBLEM SOLVED
- SUBSYSTEM B -
  - ENGINE PERFORMANCE VERIFICATION
  - DEFECTIVE PRESSURE REGULATOR
  - THRUST CHAMBER TRANSDUCER FAILURE
  - RELAY BOX VIBRATION
  - UNRELIABLE ENGINE LIQUID REGULATOR
  - IMPROVED THRUST CHAMBER WELDING
- SUBSYSTEM C-
  - INADEQUACY OF ALUMINUM WIRING
  - MICROPHONICS IN POWER SUPPLIES REVEALED
  - GUIDANCE AMPLIFIER POWER SUPPLY INSTABILITY

SANTA CRUZ TEST BASE OPERATIONS

SIGNIFICANT FINDINGS

- SUBSYSTEM D
  - STICKING PITCH GYRO DISCOVERED
  - INTERMITTENT HORIZON SCANNER OPERATION
  - D-TIMER SWITCH FAILURES
  - NOISY INTEGRATOR CIRCUIT
  - DEFICIENCIES IN N_2 GAS VALVE TRANSDUCERS
- SUBSYSTEM H
  - INADEQUACY OF TURBOPUMP RPM TRANSDUCER DESIGN
  - INTERMITTENT S-BAND BEACON
  - IMPROPERLY WIRED T/M TRANSMITTER
  - DEFECTIVE ENGINE TRANSDUCERS

SIGNIFICANT FINDINGS

SUB SYSTEM A

STEEL SEALS SUBSTITUTED FOR ALUMINUM SEALS - Oxidizer leakage traced to aluminum tank seals which were found to be nicked and scratched thereby not providing good seal. Steel seals more durable and less susceptible to such minor but critical damage were substituted.

TURBINE EXHAUST STACK MOUNTING BRACKET - Shown to be of marginal design in that it lacked the necessary rigidity. During test at SCTF it became loosened. This situation could have resulted in a possible problem during actual flight conditions. To positively preclude such a possibility the bracket was re-designed.

SEPARATION MONITOR NOISE - During engine firing the separation monitor produced high noise level blanketing telemetry transmission.

TANK SEAL DETERIORATION - Tank seal leakage noted under actual operating conditions at Santa Cruz showed that seals for propellant tanks, fuel and oxidizer scals were reversed in installation causing eventual and sometimes rapid deterioration. Such a situation could only be uncovered under actual operating conditions.

SIGNIFICANT FINDINGS

SUB SYSTEM: B

ENGINE PERFORMANCE VERIFICATION - One of the most important products of the complete vehicle systems at the Santa Cruz test base is that of Engine Performance Verification. Each vehicle tested is instrumented to measure the necessary parameters. A case in point is Discoverer XIX (1101 - BM -1). The engine, a suspected low performer, SCTB test results showed that the specific impulse (Isp) was seven (7) seconds low. Result:- Additional propellants were loaded - Flight went to integrator shutdown with indications of very small residuals.

DEFECTIVE PRESSURE REGULATOR - Found faulty operation under actual hot firing conditions. Inspection revealed discrepant casting and oversize spring. Entire lot re-inspected eliminating probability of recurrence on an actual flight.

THRUST CHAMBER TRANSDUCER FAILURE - Pressure transducer measuring thrust chamber pressure failed during early test. Found improper location, welding and support. Failure during flight could have resulted in thrust chamber failure and resultant destruction.

RELAY BOX MODIFICATION - Tolerance limits proven low during hot firing test causing a premature shutdown. Incident proved that safety margin need to be added. Demonstrated that environment produced at SCTB useful and better source than machine. Production units changed.

UNRELIABLE AGENA LIQUID REGULATOR - Original Agena A engine Model 8001 showed unreliable operation of engine liquid regulator. The regulator, a mechanical device, delivered 70% of normal flow to the gas generator, the remaining 30% being controlled by a bellows tap for constant MR. Santa Cruz testing showed possible clogging due to salting with special handling and flushing required. This was a major factor in the gas generator re-design incorporated in subsequent engines.

IMPROVED THRUST CHAMBER WELDING - Testing at Santa Cruz revealed faulty welds in the thrust chamber and oxidizer manifold assembly. Called to the immediate attention of Bell Aerosystems Co., improved welding and assembly techniques resulted.

SIGNIFICANT FINDINGS

SUB SYSTEM C

INADEQUACY OF AIRFRAME WIRING - After hot firing at Santa Cruz a number of broken leads were discovered. The crimp connectors were cutting the aluminum wire under vibration during engine firing. The aluminum was found to work-harden under crimping action. This was compounded by a personnel error in using an improperly sized crimping tool. The latter was a quality assurance inspection problem which was corrected and the aluminum wire was replaced by copper wire. The difficulty might never have been discovered without a hot firing.

INSTABILITY OF GUIDANCE AMPLIFIER POWER SUPPLY - Instability in the IMP amplifier had been noticed in Sunnyvale systems runs but could not be corrected because it was intermittent. The long land lines and checkout system at Santa Cruz introduced more electronic noise and more frequent stimulation of these amplifier oscillations. Since the condition was more prevalent at Santa Cruz it was isolated, identified, and corrected there. The trouble involved coupling with the minus 2[illegible] volt power supply. The remedy involved increasing the power supply capacity from 30 watts to 100 watts, reducing its output impedance, and redesigning the amplifier to inhibit such oscillation.

MICROPHONICS IN POWER SUPPLY REVEALED - After 10 seconds of engine firing during the Santa Cruz static test of [illegible] vehicle 10[illegible], extensive noise appeared on the minus 2[illegible] volt power supply and plus 2[illegible] volt regulator, with an amplitude of [illegible] volts. The noise continued for the duration of the engine firing. Although the source of this trouble was never identified, the vehicle was extensively reworked and suspected components were replaced. The condition was absent during a subsequent hot firing. It was thought to indicate loose wiring which might have existed during flight if undiscovered during the hot firing.

SIGNIFICANT FINDINGS

SUB SYSTEM: D

STATIC PITCH GYRO - [illegible] HORIZON SCANNER - D - THERM SWITCH FAILURES and NOISY [illegible] CIRCUIT - The foregoing four items were malfunctions occuring during hot firing at Santa Cruz. Components affected were investigated thoroughly. Problems of design and quality control were uncovered and corrected.

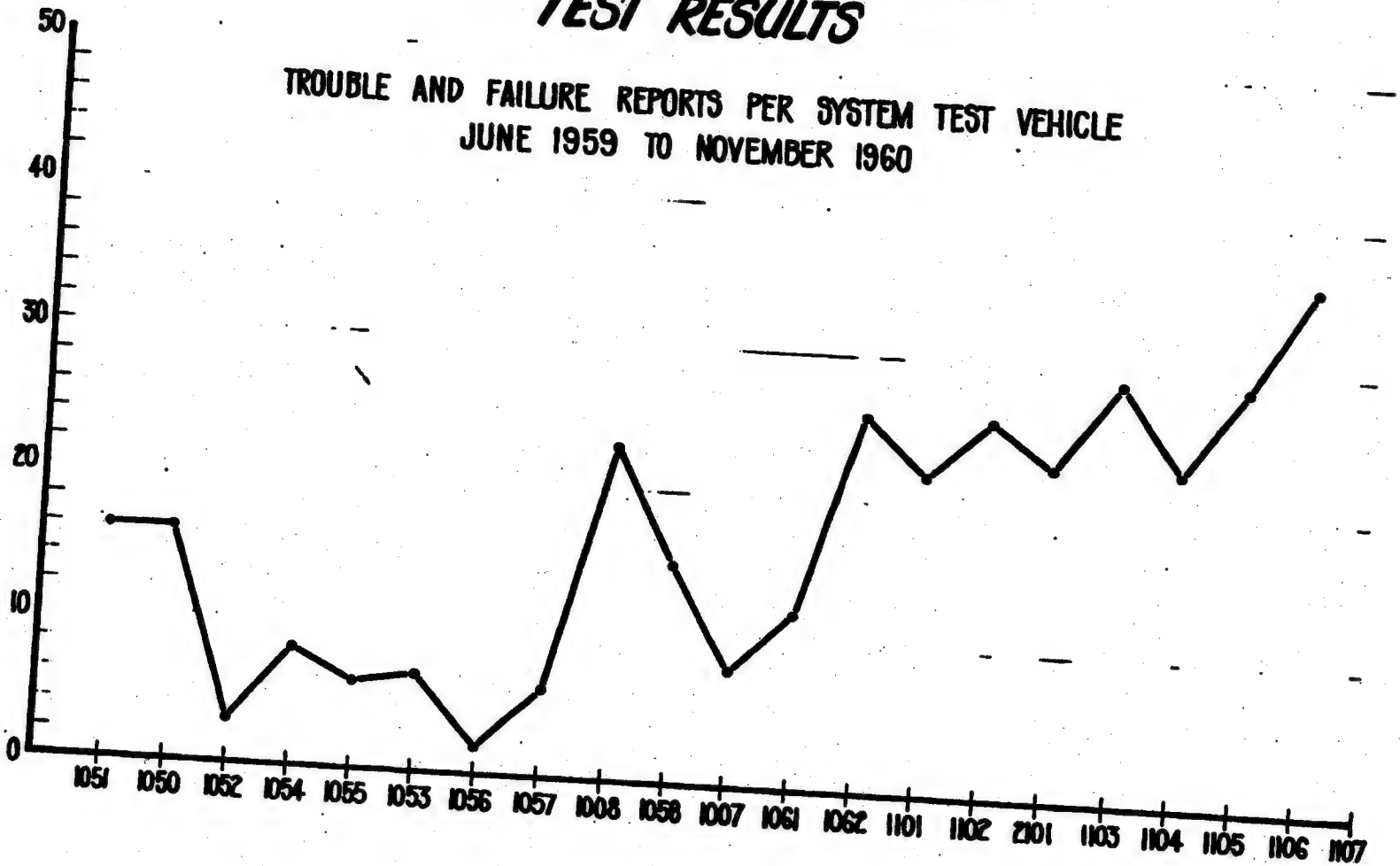
DEFICIENCIES IN N2 GAS VALVE TRANSDUCERS - Malfunctions in gas valve transducers impaired ability to determine cold gas usage rate and reserve. Better potting techniques were developed improving accuracy of data furnished.

SIGNIFICANT FINDINGS

SUB SYSTEM H

Those findings of trouble and discrepant items of equipment related to Sub System H are merely added proof of the value of testing at Santa Cruz. The inadequacy of a turbo pump [illegible] transducer design could not have been discerned in other than an engine hot firing test under true vehicle operating conditions. Engine transducers likewise cannot be determined to be defective under ordinary static conditions.

SANTA CRUZ TEST BASE
TEST RESULTS



SANTA CRUZ TEST BASE ACCOMPLISHMENTS

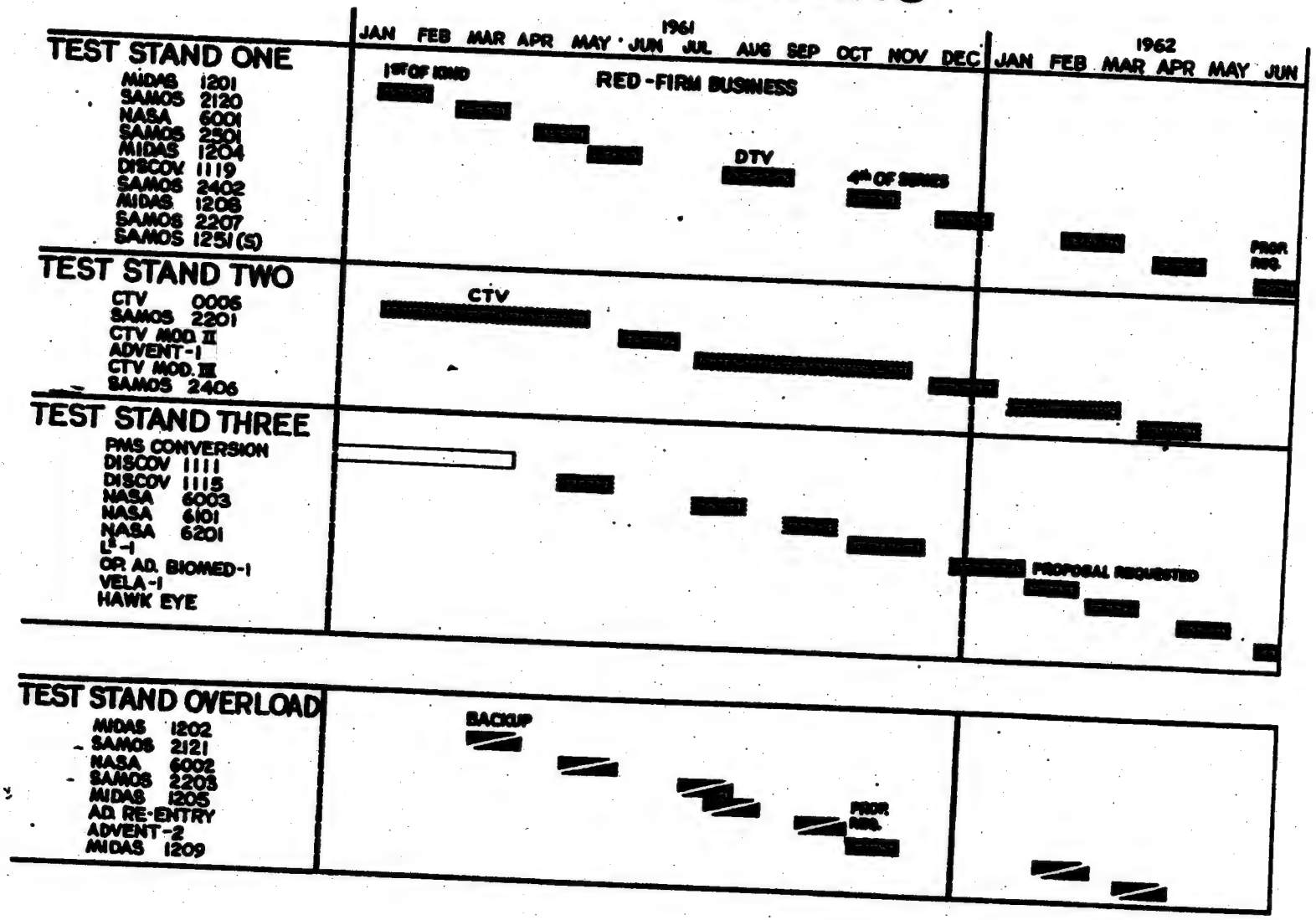
- DEVELOPED BLOWDOWN PRESSURIZATION SYSTEM - REGULATOR AND TANKS FOR RESTART MISSIONS - QUALIFIED AND DEMONSTRATED RELIABILITY IN MINIMUM TIME.
- DEVELOPED COLD GAS SPIN AND DE-SPIN SYSTEM FOR DISCOVERER CAPSULE - GAS JETS DESIGNED, TESTED AND PROVEN RELIABLE AT SCTB - UNRELIABLE SMALL SOLID SPIN ROCKETS ABANDONED.
- DEVELOPED IMPORTANT TECHNIQUES FOR PROPER ENGINE SERVICING AND MAINTENANCE - SERVING AS A TRAINING GROUND FOR ENGINEERS AND TECHNICANS IN DEVELOPING FINAL PROCEDURES OF ALL KINDS FOR FIELD USE.
    - DETERMINED MOST PRACTICABLE LAUNCH PAD PRE AND POST PROPELLANT LOADING PROPULSION SYSTEM HOLD LIMITATIONS.
    - ASCERTAINED AND SUBSTANTIATED LAUNCH PAD LAND LINE INSTRUMENTATION REQUIREMENTS FOR PAD CONTROL AND FLIGHT READINESS DETERMINATION.

SATELLITE SYSTEMS SANTA CRUZ TEST STAND LOADING

The scheduled useage of the Santa Cruz Test Stands is based on the LMSD Integrated Test Philosophy and Plan. Insofar as feasible, the first of new vehicle models and design test vehicles (DTV) of a complex nature are scheduled for testing in Test Stand One. Test Stand Two is devoted to captive test vehicle (CTV) programs excepting for 1st-of-kind vehicles that must be tested concurrently with such vehicles in Test Stand One. Until mid April 1961, Test Stand Three will be undergoing adaptations that will permit testing of both Polaris missiles and Agena vehicles. After this date Test Stand Three is scheduled for testing of NASA vehicles, 4th-in-series Discoverer vehicles, and similar types for which proposals have been requested of LMSD.

With the vehicles to be tested under firm business and which are tentatively scheduled under proposal requests, space is not available for testing backup vehicles and the possible first Advanced Re-entry Agena, without some rescheduling and disruption of the captive test vehicle (CTV) program. These vehicles are shown as a potential test stand overload. Backup vehicles are chosen as the vehicles following the first of a new model.

SANTA CRUZ TEST STAND LOADING



Satellite Systems, Santa Cruz Test Base Support Testing

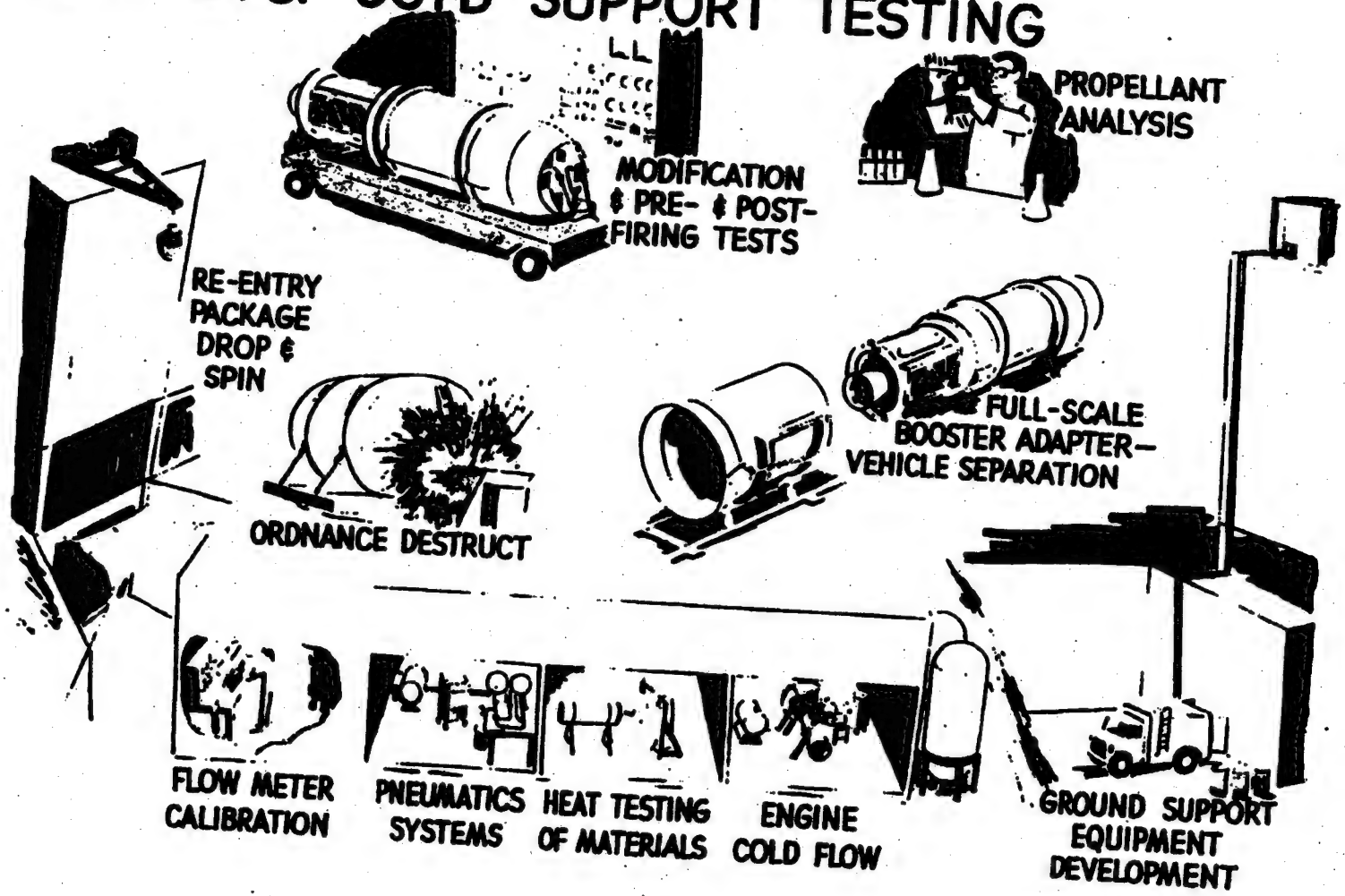
Vehicle systems testing is the major Satellite Systems effort at SCTB. Many other test operations are conducted by and for Satellite Systems in support of the Agena Program. These are generally of a hazardous nature or are such that the unique facilities at SCTB provide the logical location in which to conduct the tests. As an example, the Satellite Systems Ground Support Equipment facility was set up to conduct proof tests on propellant transfer systems, propellant conditioning equipment, umbilical couplings, and other items of ground handling and ground support. By modifying one test stand, actual launch pad vehicle heights were simulated to test remotely-controlled, complete servicing equipment and procedures.

Another test stand modification provided a 100 foot drop tower capable of nondestructive tests on re-entry packages. A more reliable spin system was developed with the assistance of SCTB Ordnance Department in time for incorporation in the next scheduled launch. It is interesting to note that the first successful capsule recovery occurred after these tests were made.

Satellite Systems personnel at the Components Test Laboratory conduct tests on complete systems as well as components. They have conducted such operations as development testing of complete vehicle pneumatic systems, engine cold flow tests, and tests to determine the ability of various materials to withstand the heating encountered in launch and re-entry conditions. A flow bench is also available for flow meter calibration and fluid flow studies.

Other SCTB Departments such as Ordnance, research and Chem. Lab. have made contributions such as tests to determine vehicle skin damage due to retro-rockets, adequacies of destruct charges, propellant and hydraulic oil analysis, development of smoke puff for Satellite re-entry tracking, and development of methods to purify contaminated UDMH.

SAT. SYS. SCTB SUPPORT TESTING



S C T B TESTS OTHER THAN SATELLITE SYSTEMS

Many tests are conducted at SCTB outside the Satellite Systems organization. The bulk of these are in support of the Polaris program and others are concerned with general LMSD research.

Six full-scale firings of the Polaris Missile Systems were made in the Polaris test stand complex between August 1958 and October 1959. Since then, the PMS personnel and facility at SCTB have been utilized in the Mate program and STV assembly and checkout, as well as de-ballast testing of the Dolphin training vehicle. In July of 1960 a re-entry thermal test facility was installed adjacent to the blockhouse, enabling efficient use of existing instrumentation and controls for re-entry body heat study tests.

The Ordnance Department at SCTB, operating within the LMSD research organization, is equipped and staffed to design, develop, qualify, and test explosive-actuated missile and satellite functions. Considerable work has been done on explosive metal forming techniques. This activity is aimed toward developing methods for producing parts from advanced metals. As one of its tools, this department utilizes a high-vacuum chamber which can handle explosive charges up to 100 grams at simulated high altitudes.

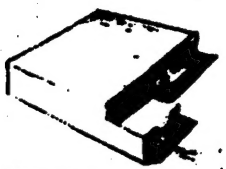
Early in 1960 a feasibility study was completed at SCTB in support of a proposed LMSD propellant research program. This resulted in the establishment of a 50-pound high energy chemical batch mixing facility which is now in operation. Test specimens produced in this facility are then tested in the LMSD Ordnance area.

SCTB TESTS - OTHER THAN SATELLITE SYSTEMS

ORDNANCE

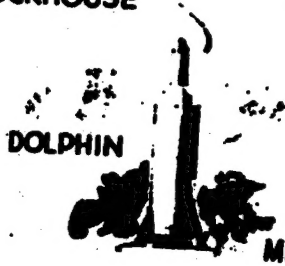
EXPLOSIVE METAL-FORMING

POLARIS

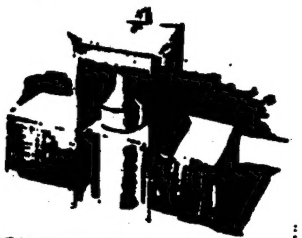


BLOCKHOUSE

RE-ENTRY BODY HEATING

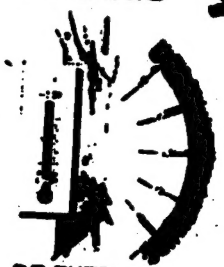


DOLPHIN

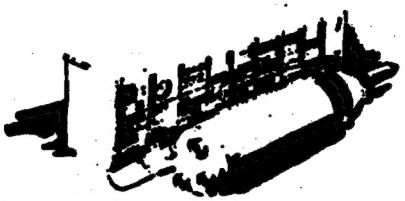


MISSILE SYSTEMS FIRING

POLARIS

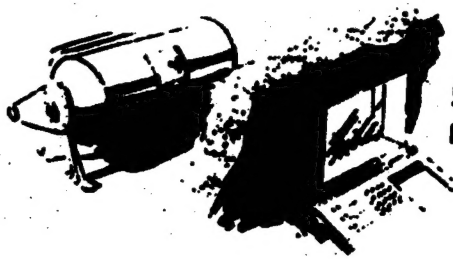
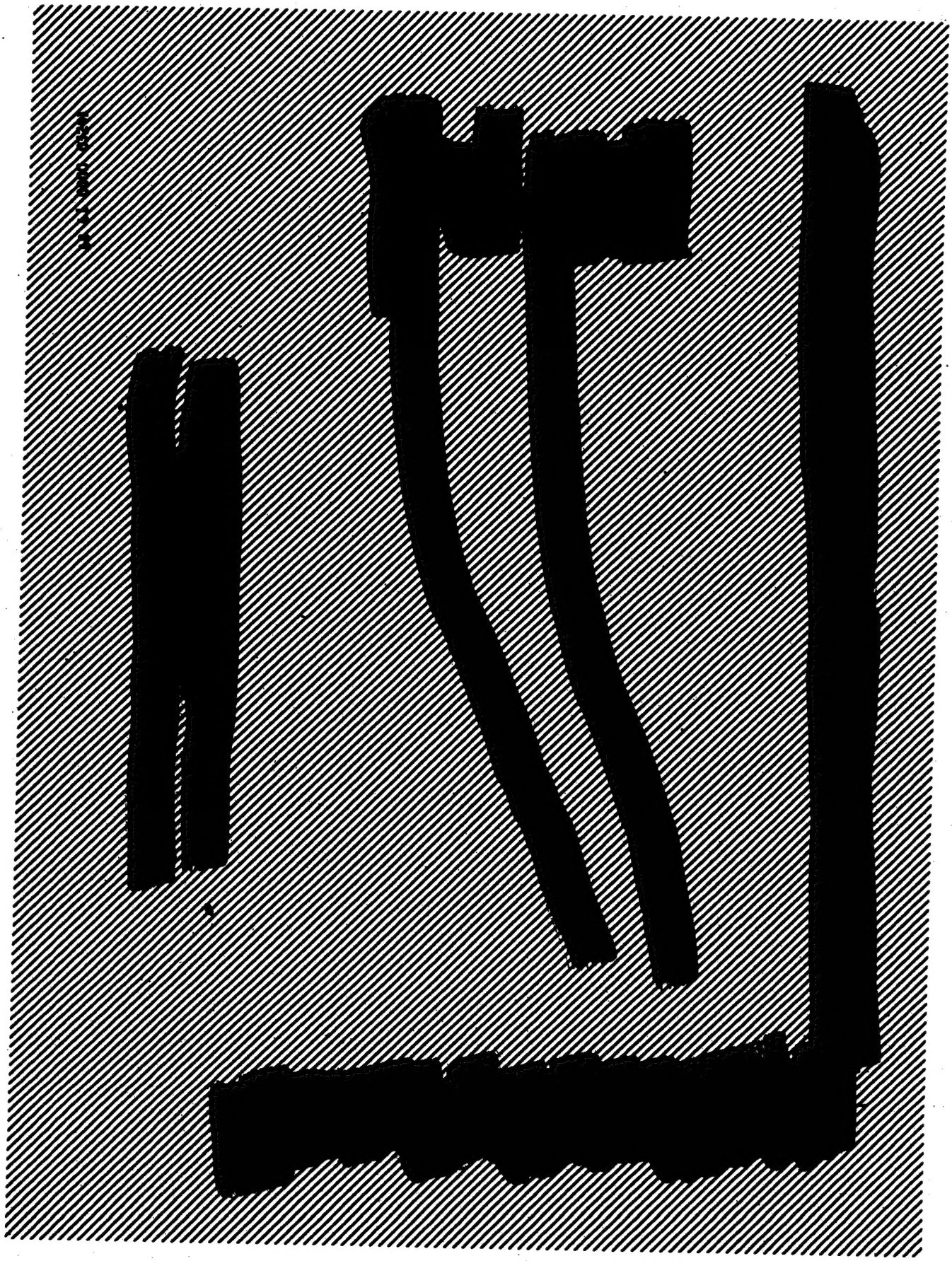
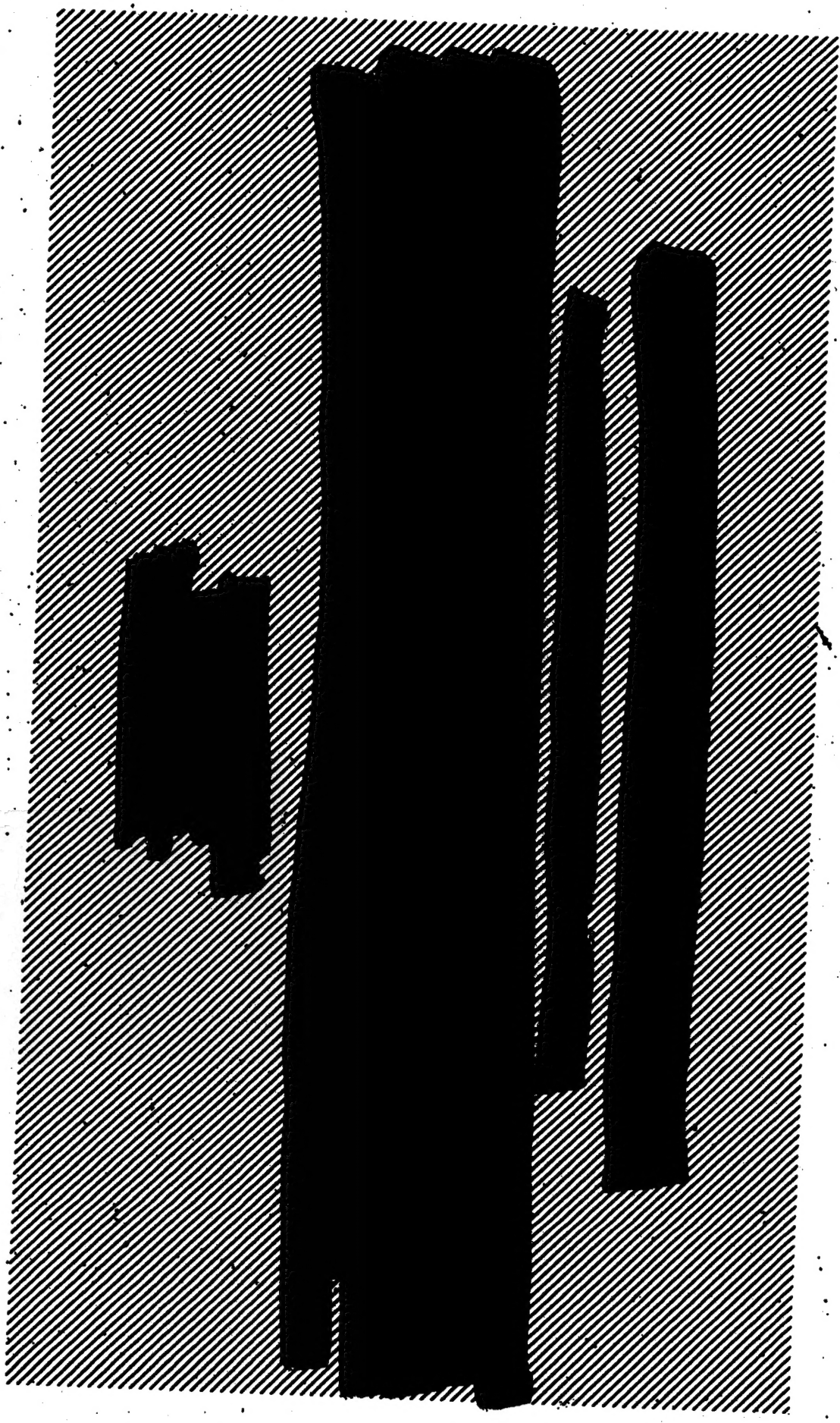


RE-ENTRY MATERIALS STUDIES



SYSTEMS CHECKOUT & NAVY PERSONNEL FAMILIARIZATION

METAL INJECTION TESTS



50 LB PROPELLANT MIXING RESEARCH